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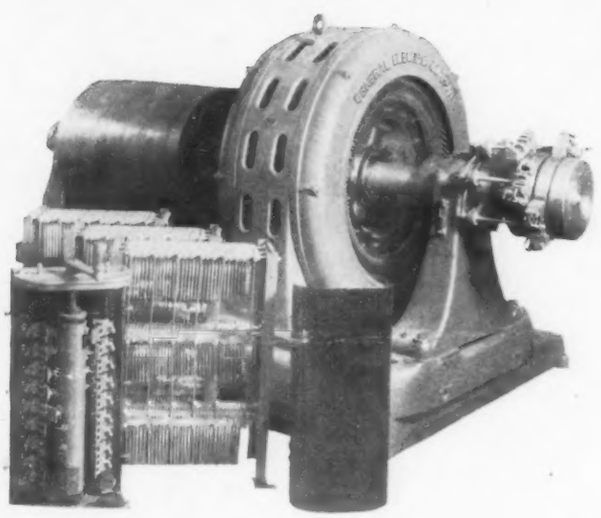

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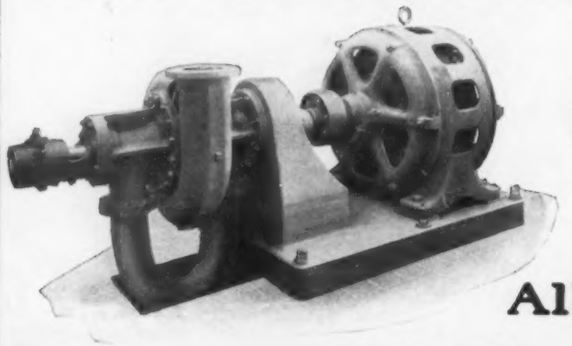

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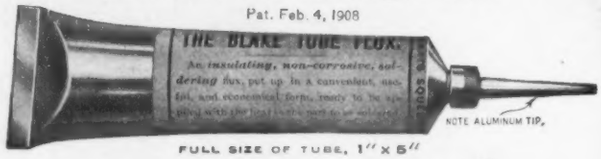

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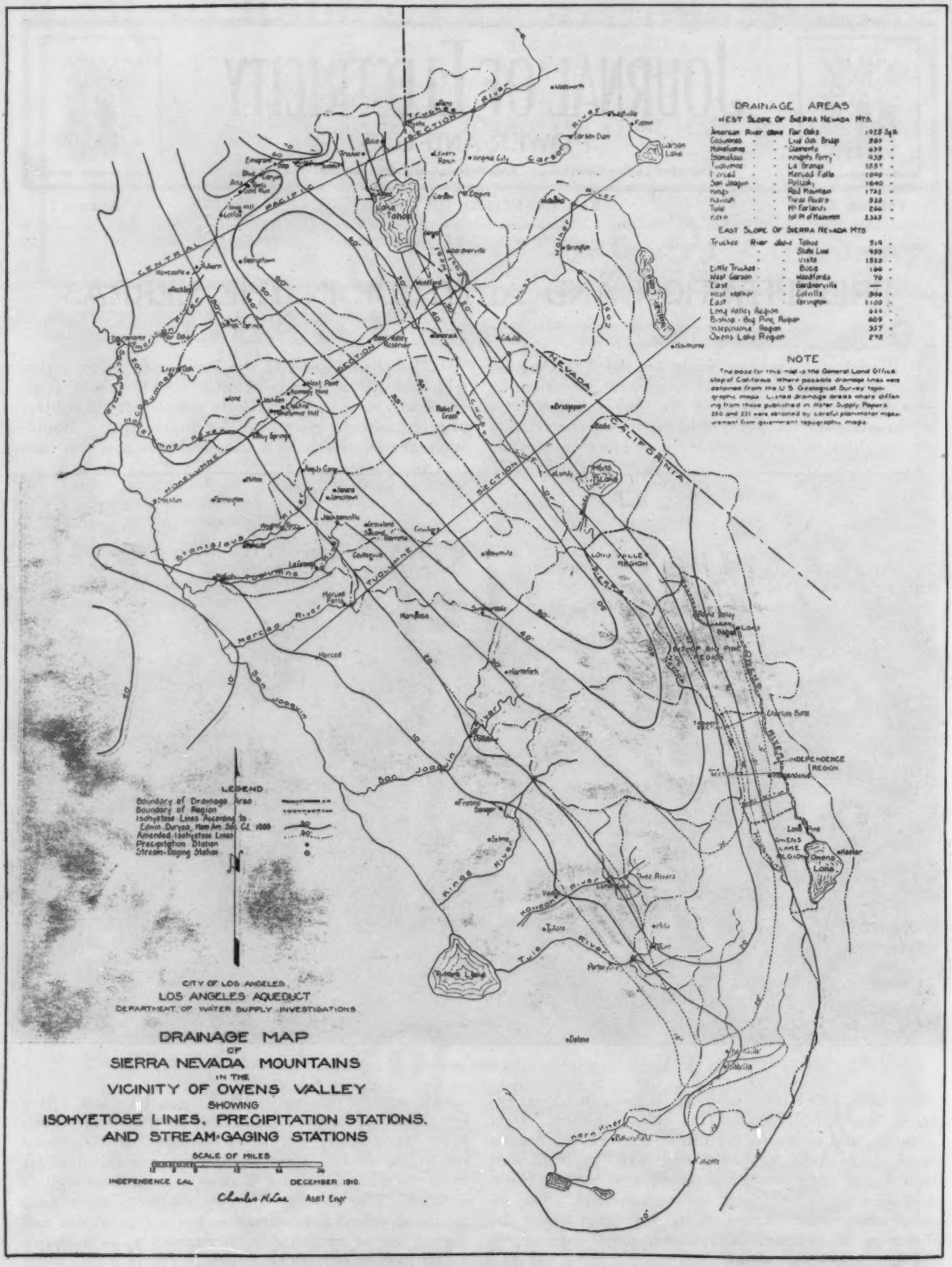
PRECIPITATION AND ALTITUDE IN THE SIERRAS

BY CHARLES H.. LEE.

Precipitation studies made by the Los Angeles aqueduct in connection with a general investigation of water-supply conditions in the Owens Valley have led to some interesting results regarding the relation of precipitation and altitude in the Sierra Nevada Mountains. The portion of the range considered extends from Lake Tahoe to the Mojave Desert. Data gathered and published by the U. S. Weather Bureau were used where available, and were supplemented on the east slope of the Sierra, adjacent to the Owens Valley, with records kept by the aqueduct. The investigations were carried on by the writer under the direction of William Mulholland, chief engineer of the Los Angeles aqueduct.

The phenomenon of the increase of precipitation with altitude is fully recognized by hydraulic engineers who have had occasion to investigate the subject of precipitation. As a basis for engineering computations the relation is often assumed to be a simple ratio, which may be applied without regard to any factor but difference of elevation. As a matter of fact however topography, prevailing winds, latitude and conditions of the atmosphere have a marked effect upon the geographic distribution of rainfall as well as altitude. The straight line relation, even when used as a convenient approximation has a limited use and should not be employed indiscriminately, as is shown by the studies herewith presented.

The High Sierras


DRAINAGE AREAS
WEST SLOPE OF SIERRA NEVADA MTS.
American River above Fair Oaks 1075 Sq.M.
Cosumnes " " Lind Oak Bridge 380 "
Mokelumne " " Clements 639 "
Stanislaus " " Knights Ferry 838 "
Tuolumne " " La Grange 1851 "
Merced " " Merced Falls 1098 "
San Joaquin " " Pollasky 1640 "
Kings " " Red Mountain 1721 "
Kaweah " " Three Rivers 338 "
Tule " " Mr Forlands 246 "
Kern " " Mt Pt of Mountain 1343 "
EAST SLOPE OF SIERRA NEVADA MTS
Truckee River above Tahoe 519 "
" " State Line 959 "
" " Vista 1810 "
Little Truckee " Boca 198 "
West Carson " Woodfords 70 "
East " Gardnerville — "
West Walker " Colville 308 "
East " Wellington 1120 "
Long Valley Region 444 "
Bishop - Big Pine Region 609 "
Independence Region 357 "
Owens Lake Region 298 "
NOTE
The base for this map is the General Land Office map of California where possible drainage lines were obtained from the U.S. Geological Survey topographic maps. Listed drainage areas where differing from those published in Water Supply Papers 250 and 251 were obtained by careful planimeter measurement from government topographic maps.
LEGEND
Boundary of Drainage Area
Boundary of Region
Isohyetose Lines According to Edwin Duryea, Mem Am Soc CE 1888
Amended Isohyetose Lines
Precipitation Station
Stream-Gaging Station
CITY OF LOS ANGELES
LOS ANGELES AQUEDUCT
DEPARTMENT OF WATER SUPPLY INVESTIGATIONS
DRAINAGE MAP
OF
SIERRA NEVADA MOUNTAINS
IN THE
VICINITY OF OWENS VALLEY
SHOWING
ISOHYETOSE LINES, PRECIPITATION STATIONS,
AND STREAM-GAGING STATIONS
SCALE OF MILES
INDEPENDENCE CAL. DECEMBER 1910.
Charles H. Lee Asst Engr
NEVADA
CALIFORNIA
OWENS LAKE
MONO LAKE
TAHOE
Truckee River
Carson River
Walker River
Mokelumne River
Stanislaus River
Tuolumne River
Merced River
San Joaquin River
Kings River
Kaweah River
Tule River
Kern River
OWENS VALLEY
LONG VALLEY REGION
BISHOP BIG PINE REGION
INDEPENDENCE REGION
Los Angeles Aqueduct

The general area within which precipitation data was considered is shown by the accompanying map (Plate 1) of the southern Sierra. Upon this are indicated the principal rivers and their drainage areas, stream gaging and precipitation stations, and isohyets or lines of equal annual rainfall. The isohyets represented by solid lines are those of the Water and Forest Association as amended in 1908 by Edwin Duryea Jr. The dotted isohyets in the southeastern portion of the area are revisions proposed by the writer based on all data available to date. The southern and eastern extension of the 30-inch and 20-inch isohyets is the most radical change and is justified by the aqueduct observations in Owens Valley.

The relations of precipitation and topography are shown in a general manner by the position of the isohyets. A more instructive method is by graphical study of observations made in and near cross-sections of the Sierra laid out at right angles to the trend of the range. Five such were chosen and are shown on the map as the Central Pacific, Mokelumne, Taboose, Oak and Bairs sections. There are sufficient observation stations along the two most northerly of these to indicate the relations upon both slopes of the range, but records applying to the three southerly sections are confined to the east slope.

A list of stations along the Central Pacific and Mokelumne sections is given on Table 1, together with elevation, distance from the Great Valley, length of record, observed and computed mean seasonal precipitations and observed precipitation during the season 1909-10. The stations selected were all within twelve miles of the sections and their elevations were such that they lay in the average profile of ground surface. (See Diagrams 3 and 6). Of stations in the Central Pacific group, Sacramento, Newcastle, Iowa Hill, Reno (1888-89 to 1909-10) and Wadsworth (1890-91 to 1909-10) are maintained by the Weather Bureau. Observations at other stations are made by agents of the Central Pacific Railway. Stations in the Mokelumne group are all maintained by the Weather Bureau. Elevations are those published in Weather Bureau reports and where possible were compared with those given on Government topographic sheets. Distances from the Great Valley were scaled from the Government topographic sheets or from the general land office map of California. Observed mean seasonal precipitation was computed for the season September 1 to August 31, The observed means are for periods of differing length and to obtain values more strictly comparable the records were computed so as to apply to a single definite period. That selected for the Central Pacific Group extended over the forty seasons 1870-71 to 1909-10, and for the Mokelumne group the 28 seasons 1882-3 to 1909-10. The method of correcting a short record was the common one of comparison with an adjacent station having a complete record.

Stations in the Taboose, Oak, and Bairs groups were established and maintained by the aqueduct. They are listed on Table 3 with elevation distance from Sierra crest, observed and computed mean seasonal precipitation. The gages were located on or near the sections at the approximate crossings of 500 foot contours. The immediate surroundings were selected with respect to accessibility from roads and trails and the recognized requirements for good exposure were

TABLE 1.

DESCRIPTION AND MEAN PRECIPITATION FOR STATIONS IN CENTRAL PACIFIC GROUP.

No. of Gage	STATION	Elevation above sea level. Feet.	Distance from Sacramento. Miles.	Length of record years	Observed mean seasonal precipitation Inches.	Computed Mean Seasonal Precipitation			Observed precipitation 1909-10. Inches.
						Base Station	No. of years Covered	Precipitation Inches	
1	Sacramento	71	0	61	19.50	Sacramento	40	19.36	12.18
2	Rocklin	249	18.9	8	28.45	Auburn	40	24.65	21.06
3	New Castle	956	26.3	15	32.32	Auburn	40	28.20	26.92
4	Auburn	1363	30.0	40	34.93	Auburn	40	34.93	36.12
5	Colfax	2421	42.1	40	49.01	Colfax	40	49.01	49.69
6	Iowa Hill	2825	46.8	31	52.64	Colfax	40	50.53	50.68
7	Gold Run	3222	48.8	11	54.49	Alta-Towle	40	43.05	48.34
8	Towle (Alta)	3612	52.8	40	49.15	Alta-Towle	40	49.15	53.02
9	Blue Canyon	4695	58.5	11	72.82	Alta-Towle	40	57.55	64.11
10	Emigrant Gap....	5230	61.7	30	53.50	Cisco	40	54.50	56.28
11	Cisco	5939	67.9	40	51.96	Cisco	40	51.96	58.85
12	Summit	7017	78.6	39	48.00	Cisco	40	47.60	37.00
13	Truckee	5820	85.8	39	27.65	Truckee	39	27.65	25.01
14	Boca	5531	92.0	38	20.47	Boca	38	20.47	25.93
15	Reno	4484	110.1	39	7.05	Reno	39	7.05	7.52
16	Wadsworth ..... (Fernley)	4084	138.4	35	4.59	Wadsworth	35	4.59	5.17

Stations 1 to 12 inclusive, Seasonal totals (Sept. 1 to Aug. 31).
Stations 13 to 16 inclusive, Calendar year totals, except last column.

TABLE 2.

DESCRIPTION AND MEAN PRECIPITATION FOR STATIONS IN MOKELUMNE GROUP.

No. of Gage	STATION.	Elevation above sea level. Feet.	Distance from Stockton. Miles.	Length of record years.	Observed mean seasonal precipitation. Inches.	Computed Mean Seasonal Precipitation			Observed precipitation 1909-10. Inches.
						Base Station	No. of years Covered	Precipitation Inches	
1	Stockton	23	0	60	15.31	Stockton	28	14.82	13.81
2	Farmington	111	13.0	33	16.47	Farmington	28	16.73	15.91
3	Ione	287	33.0	32	21.03	Ione	28	21.33	20.39
4	Valley Springs ...	673	31.2	22	24.71	Stockton	28	24.18	23.28
5	Jackson	1200	40.0	20	33.19	Jackson	20	33.19	.....
5	Mokelumne Hill..	1550	41.0	28	32.53	Mokelumne Hill	28	32.53	32.93
7	West Point	2800	52.8	16	42.50	Mokelumne Hill	28	41.15	39.56
8	Bear Valley Res..	5800	72.5	7	63.35	Mokelumne Hill	28	57.65	.....
9	Tamarack	8012	89.5	11	57.23	Mokelumne Hill	28	54.73	48.94
10	Gardnerville	4830	108.5	11	8.93	Mokelumne Hill	28	9.08	16.57
11	Wabuska	4347	141.5	7	3.70	———	..	.....	3.49

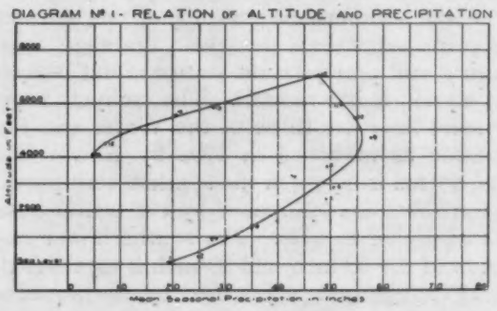
TABLE 3.

PRECIPITATION STATIONS IN OWEN VALLEY.

Number of gage	GROUP	Elevation above sea level. Feet.	Distance from crest of Sierra Nevada Mts. Miles.	Observed Precipitation in Inches Season 1908-9	Season 1909-10	Computed mean seasonal precipitation based on 26 yr. record at Independence.
2	Taboose	4070	8.1	9.09	6.65	6.56
3	Taboose	4460	6.9	10.40	7.61	7.51
4	Taboose	5040	5.5	11.74	8.69	8.53
5	Taboose	5550	4.7	16.53	9.26	10.48
6	Taboose	6190	4.2	23.24	12.94	14.69
18	Oak	3735	13.8	....	3.15	3.25
17	Oak	3775	12.5	....	4.25	4.38
7	Oak	3940	9.6	7.22	4.45	4.78
8	Oak	4300	8.4	9.24	....	6.37
8A	Oak	4500	8.0	.....	5.27	5.43
9	Oak	5030	6.6	11.35	6.42	7.22
10	Oak	5590	5.7	14.47	7.67	8.94
11	Oak	6120	4.8	21.04	10.19	12.51
12	Bairs	4100	10.2	4.28	3.74	3.40
13	Bairs	4500	9.0	6.09	3.63	3.97
14	Bairs	5000	7.7	7.63	5.34	5.38
15	Bairs	5500	6.6	11.67	5.94	7.08
16	Bairs	6100	5.7	14.34	7.24	8.68

observed. The highest level on the slope of the Sierra which can be reached from the Owens Valley after the winter snow storms is approximately the 6500 foot contour. Gages were distributed between this contour and the valley floor, which near Independence has an average elevation of 3800 feet. The type of gage used was the ordinary 8-inch cylindrical gage of the Weather Bureau. The funnel shaped receiver, however, was dispensed with so that the catch fell directly into the 8-inch cylinder. The mounted observer carried the inner tube and cedar measuring stick and poured the catch from the container into the small tube for measurement. Snow was reduced to equivalent water by weighing the catch with a spring balance. The gages were visited after each storm, an observer being detailed to each group. Snow shoes were part of the necessary equipment in winter. The exact elevation and location of the gages was determined by ordinary engineering methods. Distances from the Sierra crest were scaled from the Mt. Whitney Quadrangle of the U. S. Geological Survey. The 26-year record at Independence which was used as a basis for computing long term means is given in Table 4. The portion of this record from September, 1866 to August, 1877, was obtained under the direction of U. S. Army

CENTRAL PACIFIC GROUP OF PRECIPITATION GAGES.



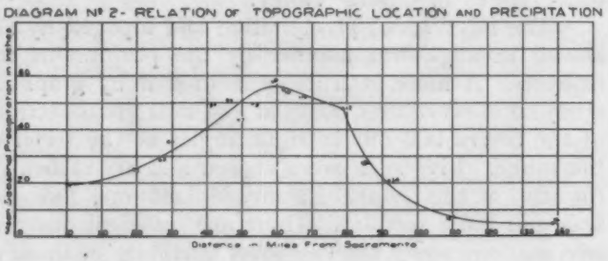


DIAGRAM Nº 2 - RELATION OF TOPOGRAPHIC LOCATION AND PRECIPITATION
Mean Seasonal Precipitation in Inches
Distance in Miles From Sacramento

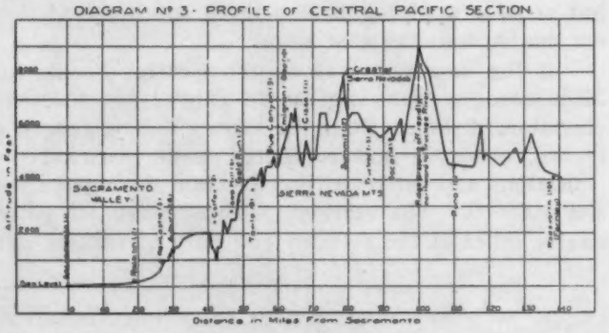


DIAGRAM Nº 3 - PROFILE OF CENTRAL PACIFIC SECTION
Altitude in Feet
SACRAMENTO VALLEY
SIERRA NEVADA MTS
Distance in Miles From Sacramento

officers stationed at Fort Independence. It was obtained under conditions sufficiently similar to permit of its being combined with the more recent Weather Bureau record at the present town of Independence.

The relations of precipitation, altitude and topographic position, and also profiles of ground surface

TABLE 4.

PRECIPITATION IN INCHES AT INDEPENDENCE, CAL.

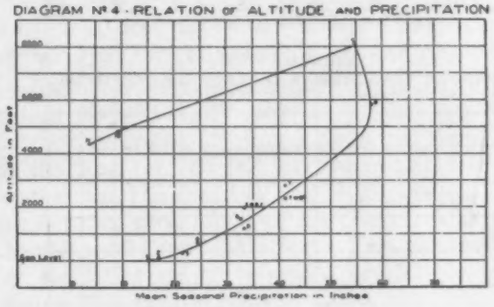
1865-1877, U. S. War Department, Fort Independence. Elevation 3930.
1892-1895, and 1898-1910, U. S. Weather Bureau, Independence. Elevation 3920.

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
1865-6	....	....	0	0.65	2.42	0	0	0.16	....	....	....	....	.....
1866-7	0	0.32	0	2.27	0	1.63	4.76	0.53	0.76	0	0.01	1.15	11.43
1867-8	0.07	0.32	0.21	12.19	5.46	0	0	0.40	0.71	0	0.10	0	19.46
1868-9	0	0.74	0.44	1.17	0.16	0	0.32	0.11	0.36	0	0.03	0	3.33
1869-0	0	0	0.14	0	0.20	1.36	0	0.21	0.27	0	0.35	0.10	2.63
1870-1	0	1.10	0	1.00	0	1.28	0	0	0	0.30	0	0	3.68
1871-2	0	0	0.65	4.70	0	0.30	0.28	0.55	0.18	0	0.28	0.12	7.06
1872-3	0	0	0	1.18	0	0.40	0	0	0	0	0	0.05	1.63
1873-4	0.10	0	0	3.40	2.40	1.00	0	0	0	0.01	0.15	0	7.06
1874-5	0.40	0.80	0.40	0	1.73	0	0	0	0	0	0	0	3.33
1875-6	0.01	0	0.66	0.62	1.51	0.70	0.87	0	0	0.15	0.19	0.56	5.27
1876-7	0.16	0.26	0	0	0.76	0	0	0.59	0.69	0	0	0	2.46
1891-2	....	....	....	....	....	....	0.62	....	0.96	0.07	T	T	.....
1892-3	0	0.35	0.23	1.61	1.51	2.91	0.98	0.02	T	0	0.77	T	8.38
1893-4	T	0	0.10	0.75	0.12	0.42	0.09	0.02	0.10	0.11	0.12	0.51	2.34
1894-5	T	0	0	1.89	1.24	1.18	0.12	T	0.01	T	T	0.04	4.48
1895-6	T	0.83	0.67	0.08	1.67	0	....	....	....	....	....	....	....
1896-7	....	....	....	....	....	....	....	....	....	....	....	....	....
1897-8	....	....	....	....	....	....	0	0.16	0.23	T	T	0.11	....
1898-9	0.20	0	0.10	0.20	0.54	T	0.01	0.02	0.03	0.37	0.01	0.06	1.54
1899-0	T	0.30	0.85	0.56	0.31	0.05	0.67	0.62	0.22	0.04	0.08	T	3.70
1900-1	0.75	0.01	1.34	0.13	2.81	0.64	0.05	T	0.36	0	0.10	0.32	6.51
1901-2	0	0.65	0.22	0.06	0.04	1.69	1.05	0.17	0.04	0.01	0.17	0.13	4.23
1902-3	T	0.08	0.41	0.04	0.71	0.27	0.34	0.19	T	0.02	0	0	2.06
1903-4	T	0.42	T	0	T	1.20	0.95	T	0.02	0	T	0.07	2.66
1904-5	0.32	0.06	0	T	0.54	0.73	2.08	T	0.25	0	0	T	3.98
1905-6	0.25	0	0.43	T	2.89	0.13	1.86	0.36	0.42	0.10	0.31	0.04	6.79
1906-7	0	0	0.02	0.84	0.95	0.56	1.10	0.14	0.01	0.55	T	0	4.17
1907-8	0	2.12	T	0.42	1.63	0.98	0.14	T	T	T	0.26	0.46	6.01
1908-9	0.84	0.03	0.01	0.20	3.27	2.73	0.16	0.12	T	T	0	0.25	7.61
1909-0	0.07	0.01	0.19	3.90	0.25	T	0.10	0.31	0	0	0.27	0	5.10
26 year. Mean	0.12	0.29	0.25	1.43	1.12	0.77	0.61	0.17	0.17	0.06	0.12	0.15	5.26

based on U. S. Geological Survey topographic maps are shown for each of the accompanying charts. The values represented by numbered points are those given in Tables 1, 2 and 3. The points at the upper end of curves for Taboose, Oak, and Bairs sections need further explanation however. As previously noted it was not practical to make complete precipitation observations above the 6500 foot contour in Owens Valley. An attempt has been made however to arrive at approximate values for precipitation along the adjacent Sierra crest from computations based on measured stream flow. Data available were the true run-off from the east slope of the Sierra measured at mouths of cañons, and an approximate value of the run-off factor. The mean seasonal discharge per square mile of mountain drainage areas crossed by the Taboose and Oak sections is 1.75 sec. ft., and by the Bairs section 1.36 sec. ft. The run-off factor for Kings River, which is adjacent to Owens Valley drainage on the west, is 0.59. Computations for the latter are based on the isohyets of Plate 1; observed variation in precipitation at Merced, Fresno, Sanger, Selma, Visalia and Summerdale; and discharge measurements of Kings River at Red Mountain covering 20 seasons. Run-off factors for the small drainage areas tributary to Owens Valley are probably larger than for Kings River for the following reasons: the greater average elevation of drainage areas tributary to Owens Valley; non-porous character of the granite bed-rock; the universal occurrence of deep cirques and cañons which favor the collecting of snow in protected drifts; the snow dust carried over the Sierra crest into the cirque basins by prevailing west and northwest winds; and the absence of lake surfaces or extensive areas supporting vegetation. All of these characteristics tend to make the run-off greater than for Kings River by decreasing evaporation and percolation losses. A value of 0.75 is thought to correctly represent run-off conditions for the Owens Valley streams.

The shape of many of the mountain drainage areas tributary to the Owens Valley is that of an isosceles triangle with apex at cañon mouth and base lying along the Sierra crest. Measuring from the Sierra crest

MOKELUMNE GROUP OF PRECIPITATION GAGES.



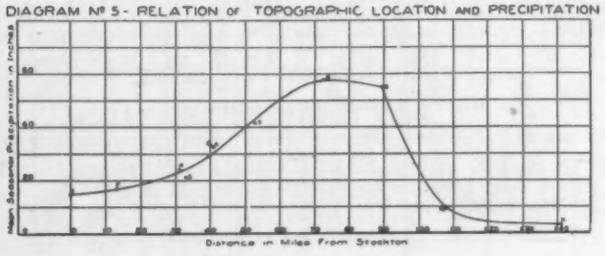


DIAGRAM Nº 5 - RELATION OF TOPOGRAPHIC LOCATION AND PRECIPITATION
Mean Seasonal Precipitation in Inches
Distance in Miles From Stockton

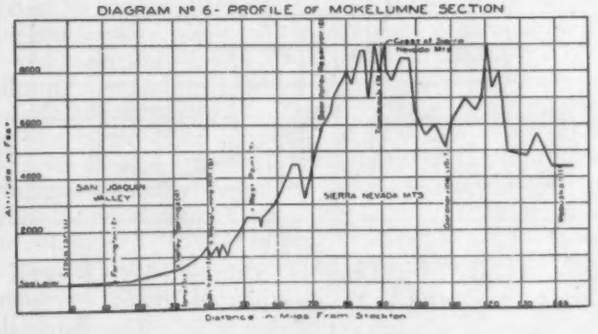
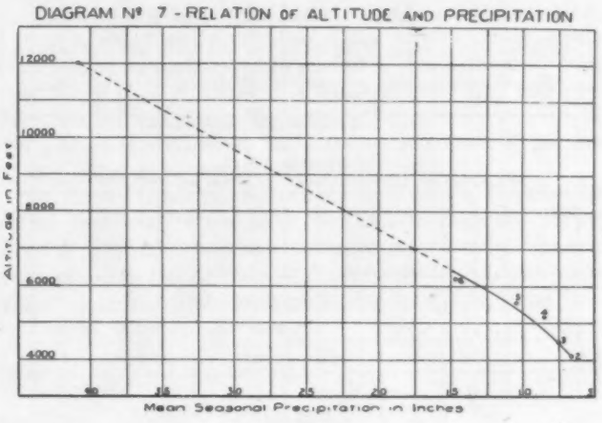


DIAGRAM Nº 6 - PROFILE OF MOKELUMNE SECTION
Altitude in Feet
SAN JOAQUIN VALLEY
SIERRA NEVADA MTS
Distance in Miles From Stockton

TABOOSE GROUP OF PRECIPITATION GAGES.



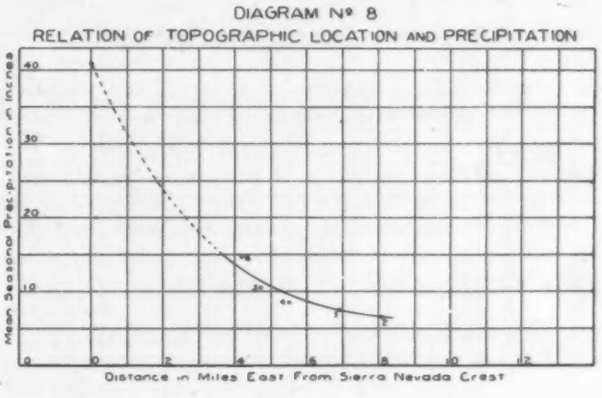


DIAGRAM Nº 8
RELATION OF TOPOGRAPHIC LOCATION AND PRECIPITATION
Mean Seasonal Precipitation in Inches
Distance in Miles East From Sierra Nevada Crest

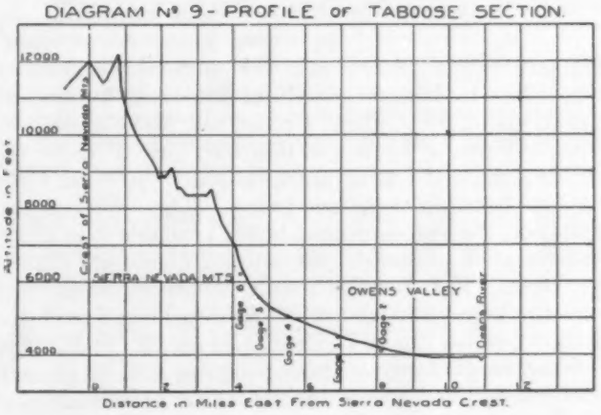


DIAGRAM Nº 9 - PROFILE OF TABOOSE SECTION.
Altitude in Feet
Crest of Sierra Nevada Mts.
SIERRA NEVADA MTS
OWENS VALLEY
Owens River
Distance in Miles East From Sierra Nevada Crest.

OAK GROUP OF PRECIPITATION GAGES.

DIAGRAM Nº 10 - RELATION OF ALTITUDE AND PRECIPITATION

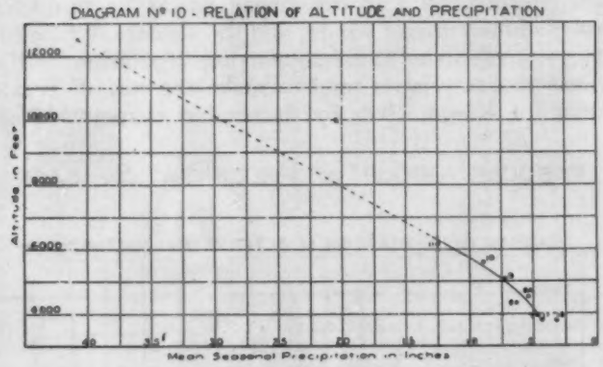


DIAGRAM Nº 11
RELATION OF TOPOGRAPHIC LOCATION AND PRECIPITATION

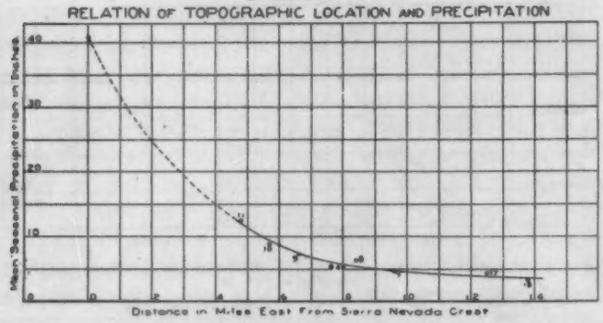
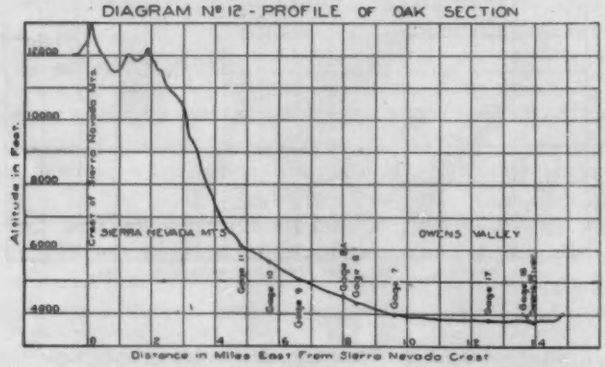


DIAGRAM Nº 12 - PROFILE OF OAK SECTION


Altitude in Feet.
Crest of Sierra Nevada Mts.
SIERRA NEVADA MTS.
OWENS VALLEY
Distance in Miles East From Sierra Nevada Crest

BAIRS GROUP OF PRECIPITATION GAGES.

DIAGRAM Nº 13 - RELATION OF ALTITUDE AND PRECIPITATION

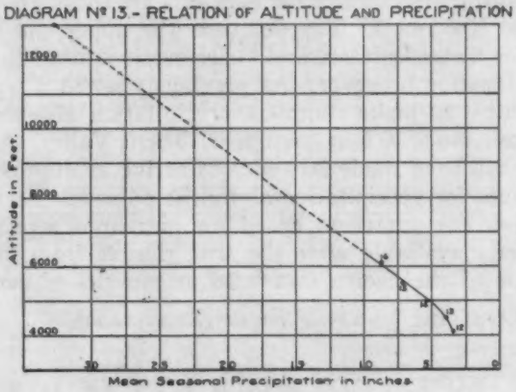


DIAGRAM Nº 14
RELATION OF TOPOGRAPHIC LOCATION AND PRECIPITATION.

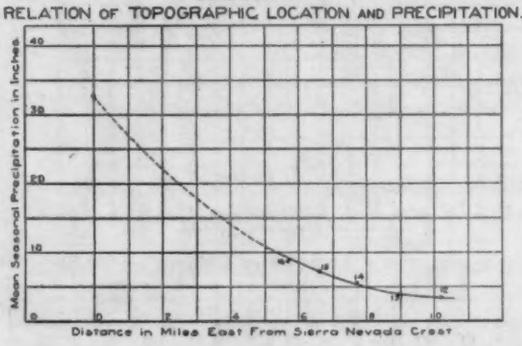
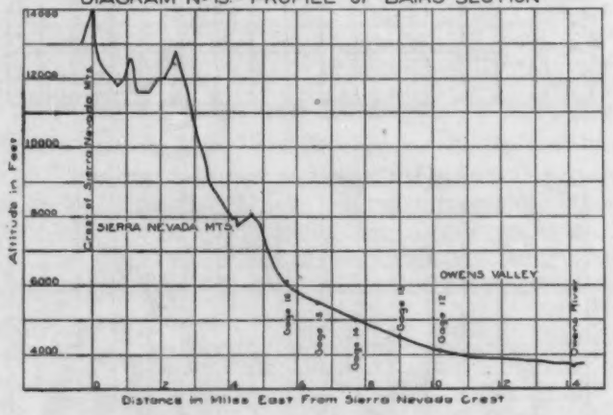


DIAGRAM Nº 15 - PROFILE OF BAIRS SECTION


Altitude in Feet
Crest of Sierra Nevada Mts.
SIERRA NEVADA MTS.
OWENS VALLEY
Distance in Miles East From Sierra Nevada Crest

and assuming a uniform rate of change of precipitation from crest to canyon mouth, as indicated by the observations in the Central Pacific and Mokelumne sections, the average precipitation over one of these triangles equals the true precipitation at one-third the distance between these two points. The observed precipitation at canyon mouths being available it is therefore a matter of simple proportion to compute that at the crest. The average depth of precipitation over drainage areas having run-off factors of 0.75 and discharges per sq. mi. of 1.75 and 1.36 sec. ft., is 31.7 and 24.6 ins. respectively. Employing the method of computation outlined above, the values for precipitation at the Sierra crest are 40.8 ins. for the Taboose and Oak sections and 32.7 for the Bairs section. These are the points not numbered on Diagrams 7, 8, 10, 11, 13, and 14,

The study of the data presented in Tables 1, 2 and 3 involves a graphical analysis of the relation of (1) precipitation to altitude and (2) horizontal position to precipitation in connection with topography. See Diagrams 1, 4, 10, 13 and Diagrams 2, 3, 5, 6, 8, 9, 11, 12, 14, 15). In general the shape of the curves which fit the platted points is similar throughout each set of diagrams. Examining the precipitation and altitude curves in detail it appears that there is an increase of precipitation with altitude from the floor of the Great Valley up the western slope of the Sierra to about the 5000 foot level. The rate of increase for this portion of the curve is greatest in the lower foothills and steadily decreases with increase of elevation. Above 5000 feet there is a moderate decrease in precipitation with increase of altitude, the rate being practically constant. East of the Sierra crest precipitation decreases rapidly with decrease in altitude, maintaining a constant rate to the 5000 foot level and a decreasing rate below this elevation. The distance and precipitation curves conform to the profile in general shape, except that their maxima are west of the topographic crests, occupying the same relative position with respect to the

Great Valley as the 5000 foot level. They have a tendency to become horizontal over the level portions of the profile to rise over western slopes below the 5000 foot contour, fall over western slopes above this contour, and to fall over eastern slopes. In other words the general slope of the country seems to have more to do with the amount of precipitation than does altitude.

Precipitation upon the plains of northern India and the southern slope of the Himalaya Mountains exhibits a similar variation. An emperical equation giving the relation of precipitation and elevation has been developed from observations in that region as follows: $R = 1 + 1.92h - 0.40h^2 + 0.02h^3$ in which R represents the amount of rain and h the relative height in units of 1000 feet above an assumed plane which was itself 1000 feet above sea level. The critical elevation was 4160 feet above sea level and observations were sufficient to determine that the form of the curve above this elevation was similar to that below, the complete curve approximating a cubic parabola whose axis is the line represented by the critical elevation. The curves on Diagrams 1 and 4 suggest a similar relation for the west slope of the Sierra, with a critical elevation of about 5000 feet. The relatively low crest of the latter range, however, breaks the relation just above the critical elevation so that the upper arm of the curve is incomplete, and a discontinuity is introduced. The relation of precipitation to elevation upon the Sierra Nevada are therefore not unique but conform to some general law.

The condition met with is the broad slope of a long mountain range presented to a prevailing moisture laden wind. The movement of a body of moist air up such a slope results in expansion and cooling of the air. When the temperature reaches the dew point condensation of the aqueous vapor occurs. The latent heat thus liberated tends to warm the air and raises its temperature above the dew point. The descent of the leeward slope of the range is accompanied by rapid compression and rising temperature of the body of air. Hence precipitation is greatest along the lower windward slopes of the Sierra, reaching its maximum at the lower cloud limit at the 5000 foot contour, decreases slowly from here to the crest of the range, and decreases rapidly down the leeward slope to the desert. It is therefore not increasing elevation alone which causes increase in precipitation, but broad rising slopes which give an upward movement to bodies of moist air driven by prevailing winds.

The conclusions form this study which can be applied in practical computations are as follows:

(1) The precipitation upon the west slope of the Sierra between the Yuba and Tuolumne Rivers increases at a variable rate which expressed as an average is 0.85 inches per 100 feet rise between the floor of the Great Valley and the 5000 foot contour.

(2) Above the 5000 foot contour it decreases approximately at the rate of 0.40 inches per 100 foot rise to the crest of the Sierra.

(3) Precipitation upon the east slope of the Sierra decreases at differing rates depending on the elevation of the crest and depth of precipitation at the summit. The rate is constant above the 5000 foot contour and for the sections studied is as follows: Central Pacific 1.74 ins. per 100 feet fall, Mokelumne 1.43 ins. per 100 feet fall, Taboose and Oak 0.46 ins. per 100 feet fall, and Bairs 0.34 ins. per 100 feet fall.

NEW SPECIFICATIONS FOR RUBBER COVERED WIRE.

In response to a number of requests we publish the new specifications for rubber covered wire (0-600 volts) recently issued by the National Board of Fire Underwriters. These have already been adopted in New York City and in Chicago and will soon be required in several Pacific Coast cities. A stock of wire meeting these requirements is now being carried on the Coast, so that contractors and others can comply with these rulings:

Rule 40 (a) Copper for insulated solid conductors of No. 4 B. & S. gauge and smaller must not vary in diameter more than .002 of an inch from the standard. On solid sizes larger than No. 4 B. & S. gauge the diameter shall not vary more than one per cent from the specified standard. The conductivity of solid conductors shall not be less than 97 per cent of that of pure copper of the specified size.

In all stranded conductors the sum of the circular mils of the individual wires, shall not be less than the nominal circular mils of the strand by more than one and one-half per cent. The conductivity of the individual wires in a strand shall not be less than is given in the following table, which applies to tinned conductors:

Number	Per cent.	Number.	Per cent.
14 and larger	97.0	23	95.2
15	96.8	24	95.0
16	96.6	25	94.8
17	96.4	26	94.6
18	96.2	27	94.4
19	96.0	28	94.2
20	95.8	29	94.0
21	95.6	30	93.8
22	95.4		

The standard for diameters and milages shall be that adopted by the American Institute of Electrical Engineers.

(b) Wires and cables designed to meet the following specifications must have a distinctive marking the entire length of the coil so that they may be readily identified in the field. They must also be plainly tagged or marked as follows:

1. The maximum voltage at which the wire is designed to be used.

2. The words "National Electric Code Standard."

3. Name of the manufacturing company and, if desired, trade name of the wire.

4. Month and year when manufactured.

Rule 41. All tests required by this rule shall apply on all wire at the time of manufacture as well as up to and including the time of installation.

(a) Copper for conductors must be thoroughly tinned.

(b) Must consist of rubber or other approved compounds, homogeneous in character, adhering to the conductor, and of a thickness not less than that given in the following table:

B. & S. Gauge.	Thickness	Circular Mils	Thickness
18 to 16	1/32 inch	250,000 to 500,000	3/32 inch
15 to 8	3/64 inch	500,000 to 1,000,000	7/64 inch
7 to 2	1/64 inch	Over 1,000,000	1/8 inch
1 to 0000	5/64 inch		

Measurements of insulating wall are to be made at the thinnest portion of the dielectric.

(c) Every length of completed wire or cable must be tested after ten hours' immersion in water, temperature to approximate 60 degrees, Fahr. (15.5 C.), and results of insulation tests at different temperatures to be reduced to a basis of 60 degrees Fahr. by using factors in the following table:

These tests must be made after an electrification of one minute and with a voltage of not less than 100 volts. Table of Multipliers to Correct Insulation Resistances at Observed Temperatures to Megohms at 60 degrees Fahrenheit.

Temp. Degs. Fahr.	Multiplier.	Temp. Degs. Fahr.	Multiplier.	Temp. Degs. Fahr.	Multiplier.	Temp. Degs. Fahr.	Multiplier.
85	2.68	76	1.88	67	1.32	58	.92
84	2.58	75	1.81	66	1.27	57	.88
83	2.48	74	1.74	65	1.22	56	.85
82	2.38	73	1.67	64	1.17	55	.82
81	2.29	72	1.60	63	1.12	54	.78
80	2.20	71	1.54	62	1.08	53	.75
79	2.12	70	1.48	61	1.04	52	.72
78	2.04	69	1.43	60	1.00	51	.69
77	1.96	68	1.37	59	.96	50	.66

Voltage tests and minimum insulation resistance to be in accordance with the following table:

TESTS ON COMPLETED LENGTHS R. C. WIRES AND CABLES, 0-600 VOLT CLASS.

Size wire	Voltage test for 1 minute.	Megohms per mile after 10 hours' immersion and after vol. test.			
14	1500	300	4	2000	150
12	1500	250	2	2000	125
10	1500	225	1	2500	150
8	1500	200	1/0	2500	125
6	2000	200	2/0	2500	125
			3/0	2500	100
			4/0	2500	100

Voltage tests and minimum insulation resistance to be in accordance with the following table:

TESTS ON COMPUTED LENGTHS R. C. WIRES AND CABLES, 0-600 VOLT CLASS.

Size	Vol. test for one minute.	Megohms per mile after 10 hrs. immersion and after voltage test			
250,000 C.M's	3000	100	700,000 C.M's	3500	100
300,000 C.M's	3000	100	800,000 C.M's	3500	100
400,000 C.M's	3000	100	900,000 C.M's	4500	100
500,000 C.M's	3000	100	1,000,000 C.M's	3500	100
600,000 C.M's	3500	100	1,250,000 C.M's	3500	100
			1,500,000 C.M's	3500	75
			1,750,000 C.M's	3500	60
			2,000,000 C.M's	3500	50

Any length may be tested after 30 days' immersion in clear water and must show not less than 50 per cent of insulation resistance required after 10 hours' immersion.

(d) Any one foot length of the completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an electro-motive force proportionate to the thickness of insulation in accordance with the following table.

Thickness in 64ths ins.	Breakdown Test on 1 foot.	Thickness in 64ths ins.	Breakdown Test on 1 foot.
1	3,000 Volts A.C.	7	16,500 Volts A.C.
2	6,000 Volts A.C.	8	18,000 Volts A.C.
3	9,000 Volts A.C.	10	21,000 Volts A.C.
4	11,000 Volts A.C.	12	23,500 Volts A.C.
5	13,000 Volts A.C.	14	26,000 Volts A.C.
6	15,000 Volts A.C.	16	28,000 Volts A.C.

The source of alternating electro-motive force shall be a transformer of at least one kilowatt capacity. The application of the electro-motive force shall first be made at 3000 volts for five minutes and then the voltage increased by steps of not over 3000 volts, each held for five minutes, until the rupture of the insulation occurs. The tests for dielectric strength shall be made on a sample of wire which has been immersed in water for seventy-two hours. One foot of the wire under test is to be submerged in a conducting fluid held in a metal trough, one of the transformer terminals being connected to the copper of the wire and the other to the metal of the trough.

(h) Test for Hardness of Insulation. The rubber or other approved compounds used as an insulation, must, after the braid has been carefully removed, be sufficiently elastic to permit all wires smaller than No. 7 B. & S. gauge to be wrapped at least five times around a cylinder of diameter as specified, and left so wrapped for twenty-four hours without injury to the insulation.

The diameter of cylinder used for any size wire shall be as follows:

Nos. 8, 9 and 10 B. & S. gauge, equal to twice the diameter of wire measured over the insulation, after removing the braid.

No. 11 and smaller, B. & S. gauge, equal to the diameter of wire measured over the insulation, after removing the braid.

Test for Softness of Insulation. The rubber or other approved compounds used as an insulation must present sufficient resistance to crushing or tension to withstand the following two tests:

Samples while being prepared for these tests shall have a temperature between 50 and 90 degrees Fahrenheit and shall be kept within these limits during the tests.

Test A. A sample of wire of sufficient length for test, about 20 inches, shall have the braid and insulation removed for about two inches at each end, leaving the braid and insulation on balance of sample. One end of the bare copper shall be fastened to a clamp on a shaft of the diameter given below, and a ten-pound weight attached to the other bare copper end of the wire. The shaft shall then be revolved ten times in ten seconds, wrapping the sample in a close, even wind around the shaft. With the tension left on the sample, it shall then be immersed in water at a temperature of 60 degrees Fahrenheit for twenty-four hours, immediately after which time it shall, while still immersed, be subjected to 1500 volts alternating current for one minute and shall show an insulation resistance equal to at least half that required by 41-c.

Diameter of Shaft, No. 14 Wire, 170 mils.
Diameter of Shaft, No. 12 Wire, 190 mils.
Diameter of Shaft, No. 10 Wire, 275 mils.
Diameter of Shaft, No. 8 Wire, 375 mils.

Test B. Sample to be tested shall have braid carefully removed for at least one inch from one end. The wire itself shall be connected to one terminal of an electric circuit, of which a testing tool, described in the following paragraph, shall be the other terminal. This circuit shall have a potential of at least 100 volts alternating, or 140 volts direct current and a resistance of at least 1,000 ohms.

The portion of the wire with braid removed shall be placed on a flat surface and subjected to a pressure, vertically applied by means of the edged tool mentioned above, of five pounds for fifteen minutes. The tool edge shall be sharp and the sides of the edge shall form an angle of 90 degrees with each other. During this period the tool edge, when placed transversely to the insulation shall not sink through sufficiently to touch the copper wire and complete the electric circuit.

(i) All of the above insulations must be protected by a substantial braided covering, properly saturated with a preservative compound. This covering must be sufficiently strong to withstand all the abrasions likely to be met with in practice, and must substantially conform to approved samples submitted by the manufacturer.

WEATHER-PROOFED ELECTRIC CABLE FOR CHINA.

A list follows of firms in Shanghai which tendered for 21 miles of water-proofed electric cable for the use of the Shanghai municipal council. The table includes name of manufacturer in most instances and price, which has been converted from sterling quotations at $4.83.

Shanghai firms.	Manufacturer.	Delivery (weeks)	Quotation.
Garrels, Borner & Co.	Felton & Guilleaume	14	$5,288
Arnhold, Karberg & Co.	Not given	12	5,540
Anderson, Meyer & Co	General Electric Co.	15	5,655
Shewan, Tomes & Co	U. S. Steel Products Co.	18	5,723
Siemssen & Co	Bergmann Electrical Works	16	5,738
W. T. Henley	Henleys, Woolwich	14	5,762
Innis & Riddle	Union Cable Co.	17	5,926
Scott, Harding & Co	British Insulated Co.	13	6,018
Jardine, Matheson & Co	Bergmann Electric Co.	18	6,110
Brighten, Malcolm & King	Callenders (Ltd)	14	6,549
Siemens China Electric Co.	Siemens Bros. & Co.	15	6,844
Melchers & Co.	Cassierer & Co.	12	6,882

STEAM SHOVEL FOR DITCHING.

A number of types of machines have been devised for ditching, trenching, canal building, etc., but in most cases their use has been limited to low flat lands where large quantities of earth were to be moved cheaply, or in cities where water gas or sewer pipes were to be laid at some distance below the ground surface. The most universal machine of this character, suitable for the heaviest sort of work and which may be used in almost any sort of working is the well known steam bucket shovel.

For all sorts of railroad work the steam shovel has long been found indispensable, but it is within only the last few years that so radical a use has been made as to build mountain roads or to construct large power or irrigation canals in the rugged mountain section of the West. The cost of mountain roads is necessarily high and when the road is through an inaccessible region, where it is difficult to procure labor, where all supplies must be hauled many miles and where the excavation consists largely of large boulders or solid rock, hand road making becomes almost impossible.

The first thought in the use of a steam shovel for this work is the cost of the apparatus and then the

Ditch Digging with a Steam Shovel.

cost and difficulty of transportation from the nearest railroad station to the point many miles away where the work is to commence. This is of course the principal part of the first cost. The results of work of this kind in the Kings river canyon in California were most important, in that the shovel once on the road was found to operate satisfactorily, moving or rolling the large boulders, stumps and logs with ease and all other rock left from blasting. The cost of this road, including the cost of the shovel was but 50 per cent of the cost of hand labor previous to the use of the shovel and the rapidity of construction several times greater. For work of this sort there might be some districts where the question of fuel would be difficult of solution, but in most cases fuel is near at hand or easily procured.

The most important work which the steam shovel has accomplished, however, in the mountain sections is in the construction of earth canals of large capacity. This work is now being done in California and elsewhere on a large scale and the results are most gratifying. An earth canal following a mountain side and having capacity for 300 to 500 second ft. flow represents a large amount of excavation. To do this by hand work is more costly per yard of excavation than it would be in a small canal of say 50 second ft. This is because earth must be handled more than once due to the depth of the cut and the height of the dump

Ditch Excavated by Steam Shovel.

bank. In any case the cost including the blasting which may be necessary can easily amount to a figure that might make a project, as an investment, unadvisable. The steam shovel is admirably suited for such work and the ease and certainty of operation, even where the ground excavated must be blasted, makes this method of carrying large quantities of water economical and advisable in some localities. The cost of canal built in this manner is from one-half to one-third the cost of hand work; it, as in road making, is much more rapid and the amount of blasting and the resulting shaking of the canal walls is less, thus insuring a more permanent structure. The shovel does not leave the canal in a finished condition as in some of the special trench excavators, hence there is always necessity for trimming and cleaning up. But the principal object is best accomplished with this machine, that of excavation.

THE COST OF CONCRETE AT PANAMA.

There is a slight increase in the cost of concrete at the Pedro Miguel Locks due to a smaller yardage, consequent upon a portion of the construction plant having been moved to the locks at Miraflores. The cost of $5.2131 per cu. yd. for the quarter is, however, below the estimate of $8.25 a cu. yd. made in October, 1908. At Miraflores, although only a part of the construction plant was in operation, 76,087 cu. yds. of concrete were produced during the quarter at an average cost of $4.8434 a yard, as compared with $8.22 a yard, the estimate of October, 1908.

PROPERTIES AND USES OF DOUGLAS FIR.

In Bulletin 88 of the Forest Service Mr. Garvey Kline and J. B. Knapp present the facts about the mechanical properties and uses of Douglas fir which have been collected by the Forest Service. It may, perhaps, be considered as the most important of American woods. Though in point of production it ranks second to southern yellow pine, its rapid growth in the Pacific Coast forests, its comparatively wide distribution, and the great variety of uses to which its wood can be put place it first. Estimates of the available supply range from 300,000,000,000 to 350,000,000,000 feet board measure. It is extensively used in the building trades; by the railroads in the form of ties, piling, car, and bridge material; and by many of the manufacturing industries of the country. As a structural timber it is not surpassed, and probably it is most widely used and known in this capacity. The species is most abundant and attains its largest size not far above the sea level in southern British Columbia and in the region between the coast of Washington and Oregon and the western foothills of the Cascade Mountains. Here large trees crowded close together rise to a height of from 200 to 300 feet, forming, either alone or mixed with hemlock, very dense forests that yield from 35,000 to 60,000 board feet per acre and sometimes as much as 100,000, and in one recorded instance 500,000 feet.

The wood is strong and hard, not very heavy, and fairly durable. These qualities particularly recommend it for structural purposes. The grain is straight. The spring and summer wood vary greatly in density; the spring growth is soft and spongy and almost white in color, while the summer wood is hard and flinty and very dark. The grain varies from as few as four or five rings to the radial inch to as many as forty-five.

In the eastern part of its range in the Rocky Mountain region, where the rainfall is not abundant and where extremes of climate occur, the trees are much smaller, rarely over 1½ ft. in diameter and over 90 ft. high. In this section the stand ranges from 2000 to 8000 board ft. per acre.

Douglas fir is known by various names in different sections of the country. The most common names and the States in which they are used are:

Douglas fir (Utah, Oregon, Colorado, Washington).

Red fir (Oregon, Washington, Idaho, Utah, Montana, Colorado).

Douglas spruce (California, Colorado, Montana).

Yellow fir (Oregon, Montana, Idaho, Washington).

Spruce (Montana).

Oregon pine (California, Washington, Oregon).

Fir (Montana).

Red pine (Utah, Idaho, Colorado).

Puget Sound pine (Washington).

General Results of Tests.

Tests on 8 in. by 16 in. by 16 ft. bridge stringers gave the following average stresses. The likelihood of variations from these averages, due to defects in the timber and to other causes, is discussed under separate headings.

TABLE 1.—RESULTS OF TESTS ON GREEN DOUGLAS FIR BRIDGE STRINGERS.

	Fibre stress at elastic limit	Modulus of rupture	Modulus or elasticity 1000 lbs. per
	Lbs. per sq. in	Lbs. per sq. in.	sq. in.
Selects:			
Green	4,346	6,753	1,654
Air-dry	4,690	7,070	1,644
Merchantable:			
Green	3,895	5,878	1,481
Air-dry	4,625	6,472	1,567
Seconds:			
Green	3,538	5,185	1,328
Air-dry	3,740	4,551	1,280
All grades:			
Green	4,000	6,000	1,510
Air-dry	4,467	6,327	1,540

The properties of green material as derived from tests on small pieces free from defects as follows:

TABLE 2.—RESULTS OF TESTS ON SMALL CLEAR PIECES OF GREEN DOUGLAS FIR.

	Pounds per sq. in.
Bending:	
Fiber stress at elastic limit	5,500
Modulus of rupture	8,400
Modulus of elasticity	1,600,000
Compression parallel to grain:	
Crushing strength at elastic limit	3,600
Crushing strength modulus of elasticity	4,100
Shearing	770

1. By careful air-seasoning to a moisture content as low as 15 per cent the strength of small clear specimens may be increased approximately 35 per cent.

2. Douglas fir varies greatly in quality, the different strength functions ranging in value 50 per cent above and below the averages quoted.

3. The analyses of the results to determine the relations existing between physical characteristics and mechanical properties of the wood show—

(a) That so-called red and yellow fir have practically the same strength; the yellow fir, however, contains fewer defects and is much more uniform in rate of growth.

(b) The mechanical strength varies directly with dry weight; that is, the heavier the wood the greater is its mechanical strength. The average oven-dry weight of Douglas fir is 28.8 pounds per cubic foot; the average weight of the green material is, approximately, 38.4 pounds per cubic foot; and the average weight of thoroughly air-seasoned material is, approximately, 33.1 pounds per cubic foot.

(c) The greatest strength of Douglas fir is most frequently associated with the rate of growth between 12 and 16 rings per radial inch.

(d) Knots and cross grains are the most significant factors in grading Douglas fir in structural sizes. The size and position of knots and the condition of the wood around them should be considered in judging their effect on the mechanical properties of the wood. The presence of knots appreciably decreases the strength of green Douglas fir in compression parallel to grain; the decrease is 22 per cent with knots greater than 1½ inches in diameter; 14 per cent with knots less than 1½ inches and greater than one-half inch, and 6 per cent in knots one-half inch in diameter or less. The decrease in compression strength at the elastic limit is 22 per cent, 13 per cent and 5 per cent, respectively. (See Table 6.) In beams the presence of knots affects most the modulus of rupture; the fibre stress at the elastic limit and the modulus of elasticity apparently

are more dependent upon the quality of the wood, and are much less influenced by such defects.

4. The tendency of specifications for Douglas fir in structural sizes is toward too great severity. The efforts to secure high-grade material generally result in throwing out much material of high structural merit. The specifications adopted by the American Society for Testing Materials and the American Railway Engineering and Maintenance of Way Association in a slightly modified form appear to be the most effective yet devised. In framing specifications, in addition to the points already brought out, the following general conclusions are of interest:

(a) Sound knots 1 inch or less in diameter which do not cause a marked disturbance in the grain should not be regarded as defects in structural timber.

(b) Sound knots larger than one inch in diameter should not be regarded as defects when they occur on the vertical faces and at a distance from the edge equal to at least one-fourth the height of the piece.

(c) Knots and cross grains which interrupt the continuity of the grain within 2 inches of the edge should not be allowed except in the lowest grade.

(d) Diagonal grain, due to sawing, that has a slant greater than 1 inch in 45 should not be allowed in the higher grades.

5. Douglas fir dimension stock seasons rapidly on the Pacific Coast between April and October; in three months the loss of weight in 8 in. by 16 in. by 16 ft. pieces is approximately 40 pounds out of a possible 60 pounds. During the subsequent rainy season timbers cease to lose weight, but during the second summer they reach a thoroughly air-dry condition.

Douglas fir is manufactured into almost every form known to the sawmill operator, and much round or hewed timber is used which never passes through a sawmill. A list of such forms and uses would represent many industries and would include piling and poles; mine timbers, railway ties, and bridge and trestle timbers; timbers for car construction; practically all kinds of lumber for houses, material for the furniture maker and boat builder; special products for cooperage, tanks, paving blocks, boxes, and pulpwood; fuel; and a long line of miscellaneous commodities including wood for distillation.

Poles.

Railroad and telegraph companies use a limited number of Douglas fir poles in regions where this timber is cut. Usually the poles are logged from forest land where clean cutting is practiced, but occasionally second-growth stands are logged for poles alone. The young tree's long, tapering trunk gives it an admirable form for this use, but it can not compete with the abundant and more durable western red cedar, and to that fact is due the limited use of Douglas fir for poles in regions where the cedar may be had. Its use for poles is restricted chiefly to county telephone and telegraph lines and to lines for carrying block-signal wires, in regions where the cedar is more difficult to obtain. As the supply of cedar poles diminishes, and a satisfactory butt preservative treatment is developed for Douglas fir, it may be substituted for cedar. Large and attractive sawed poles of fir are in use on many electric car lines in cities where utility and handsome appearance are combined. Some of the street car lines in the vicinity of Washington, D. C., are equipped with Douglas fir poles.

Railway Ties.

Ties of Douglas fir are both sawed and hewed, though three-fourths are sawed. Much of the inferior timber in logging operations is worked into ties. Those which are sawed are made both from second growth and from mature trees. About two-thirds of the ties supplied by the forests of the western part of the United States are of Douglas fir, the remaining one-third consisting chiefly of western yellow pine, lodgepole pine, redwood, and western hemlock. Practically all the large sawmills in Washington and Oregon cut fir ties to order, and some small mills cut little or nothing else. It is customary to saw ties from a large portion of low-grade material obtained in the usual milling operations. Douglas fir generally yields about 25 per cent of high-grade lumber and the remaining 75 per cent must be worked into lower grade lumber, dimension products, timbers, and ties. Though the season in which the trees are cut probably influences the durability of the wood, no consideration is given to this element by the tie makers. A set of standard specifications which shows the requirements of Douglas fir ties follows:

Specifications for Sawed Ties.

Ties must be sawed out of red or yellow fir, and must be 7 inches thick, 9 inches wide, and 8 feet long. They must be sawed out of sound, straight, live timber, and must be free from bark, splits, shakes, sheathing and rough structural purposes, or, when shipped, is sold in the Plains States east of the Rocky Mountains and adjacent regions. The distribution of dimension material does not differ greatly from that of common lumber, except that a considerable quantity is exported to China, Japan, the Philippine Islands, and elsewhere. The large size timbers, however, go all over the world. The Orient depends largely upon them for heavy construction, as does the entire western part of the United States. Much of the massive timbering required by the Panama Canal is of this wood, and large shipments go regularly to Australian and Japanese ports, where they are resawed into various building forms. Europe affords a market, as do the Atlantic Coast States, for many cargoes of Douglas fir timbers that compete successfully with the yellow pines of the South. Douglas fir lumber is very widely distributed in all the countries of the Orient, in most European countries, South Africa, South America, and the South Sea Islands. Large amounts of it are sold in the central and eastern parts of the United States through retail yards.

Conduits.

The manufacture of conduits and water pipes is near akin to cooperage. Staves are largely used in the construction of conduits, and high-grade Douglas fir supplies great quantities. Such staves are made from flat-grained lumber, with the wood as nearly of uniform growth as may be had. They are made in such shape as to give the finished conduit a cylindrical

form, and its different parts are so closely fitted as to make it waterproof. When the pipe is 24 inches or less in diameter it is constructed from staves of special pattern, with grooved edges. Such pipes are built up at the factory, and are wound from end to end with mild steel wire, after which the exterior is covered with an asphalt-and-tar mixture for preservative purposes. The thickness of the staves and the pitch of the wire reenforcement varies according to the pressure under which the pipe is to be used. Conduits larger than 24 inches are set together at the place where they are to be used. Such pipes are always continuous, the staves being so placed as to break the joints. In large conduits the staves are usually 6 inches wide, with beveled edges, and are curved to conform to the diameter of the pipe. When the staves have been set in place, the pipe is drawn tight with steel bands and bolts, and all the joints are closed. Conduits thus constructed form important parts in the water systems of many western towns and cities, and are widely used for manufacturing plants, irrigation works, hydraulic mining, dredge work, oil pipes, wire conduits, for steam-pipe casing, and for various other purposes. Douglas fir pipes of this kind are used not only in the Pacific Coast States, but also in the Eastern and Middle States, in British Columbia, and in Alaska.

TELEGRAPH EXTENSION IN CHINA.

The Chinese telegraph administration, in view of the close working arrangements with the eastern extension, Australasia & China Telegraph Co. (Ltd.), British, and the Great Northern Telegraph Co. (Ltd.), Danish, on April 10 concluded an agreement with the two last-named companies whereby it is to receive an advance of £500,000 ($2,433,250) on the foreign traffic dues of the next 18 years; that is, the two companies are to have as security a lien on the balances payable by them on the Chinese telegraphs under the joint-purse agreement of July 11, 1896. This agreement and, in fact, all other existing agreements and concessions between the administration and the companies were extended to December 31, 1930, according to agreements signed by them August 4, 1900, and October 27, 1900. (See Hertslet's China Treaties, vol. 2, document Nos. 182 and 198.) Half-yearly adjustments of the principal are to be made, and the advance is to be made at par and carry interest at 5 per cent, which the rates at present cover.

It is stipulated that the money is to be utilized only for the development of telegraphs and telephones, and that the telegraphic charges on the land lines in China should be restricted to 10 cents Mexican (4 1-3 cents American currency) per word for all points within a Province and 14 cents (6 cents American) per word between all points within any two adjoining Provinces.

Any improvements and extension in telegraphic communications and in installing systems of telephones, as those contemplated by this loan, should create a demand and thus offer a promising market for appliances of all varieties along the above-mentioned lines.

TRANSMISSION SYSTEM OF THE GREAT WESTERN POWER COMPANY.[1]

BY J. P. JOLLYMAN.

The Great Western Power Company operates a long-distance, extra high-tension transmission system which extends from its hydroelectric plant at Big Bend, 16 miles north of Oroville, Cal., to Oakland, Cal. The nominal line voltage is 100,000, at 60 cycles. The length of the main line is 153.6 miles. A branch line 1.1 miles long taps the main line 136.5 miles from Big Bend. Both the main and branch lines are double circuit. Both are supported on steel towers.

1. The high tension sides of all the transformers are delta connected. There is no connection to ground, except through the electrolytic lightning arresters.

2. One ground wire, supported on the apex of the towers, is used. This is grounded at every tower.

3. The standard span is 750 feet; 3/0, seven-strand copper cable is used on the main line, No. 6 copper on the branch. Each circuit is completely transposed about every 10 miles. The arrangement of the conductors is shown in Fig. 1.

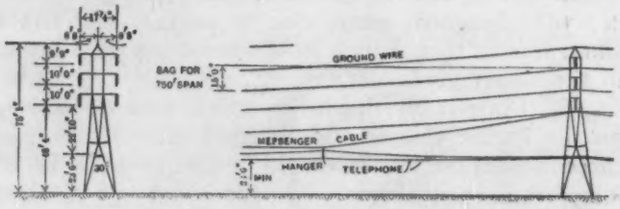


Fig. 1.

The longest span with regular towers and cable is 1998 feet. The longest span is 2740 feet. This is across the San Joaquin River near Antioch. Special towers are used. The conductors clear high water 125 feet. The six conductors are in a horizontal plane, 15 feet apart.

4. We have never yet had any lightning whatever .

5. The measured value of the charging current is very nearly the same as the value determined by using the ordinary formula for charging current based on the capacity of two parallel conductors. The distance between the conductors is taken as the average distance of 13.33 feet.

VALUES OF CHARGING CURRENT.

Volts at Big Bend	Computed Current	Observed Current	Kv-a.
70,000	35.7	36.0	4360
80,000	40.8	41.5	5750
90,000	46	47	7330

6. Line insulators used. General Electric strain type, Locke strain type, Thomas strain and suspension types. Only three or four insulators have broken down during the past year. In no case have we any reason to believe that the insulators may not have been damaged mechanically before it failed electrically. We consider that the suspension insulator is a success.

We have had no trouble with swinging of conductors wth suspenson insulators.

7. General Electric type T and type K-10 oil switches are both used. We have had no difficulty in

[1] Paper presented at the 28th Annual Convention of the American Institute of Electrical Engineers, Chicago, Ill., June 26-30, 1911.

opening load, short circuit or charging current. The indications are that these switches could be safely used on a considerably larger system than we now operate.

8. We have all kinds of load connected to our system, including synchronous motors. No attempt is made to neutralize the charging current by reducing the field on any synchronous load. Under ordinary conditions the power factor at the generating station is nearly unity.

For the convenience, speed and safety of operation, each generating unit should have a capacity of at least equal to the charging current of one line. In our case this means units of about 10,000 kw. We have at present four 10,000 kw. generators at Big Bend, each with a 10,000 kw., three-phase transformer. The station is planned to ultimately contain eight 10,000 kw. units.

9. Transformer Terminals. Oil-filled terminals were supplied. It has been found difficult to maintain them free from the possibility of leakage. They have been refilled with compounds designed to reduce the chance of leakage.

Oil Switch Terminals. We have used compound-filled terminals. Experience has shown that compounds for use in high-tension terminals must be very carefully tested in practical operation before their suitability can be decided upon.

Outlets. The outlets from our buidings are primarily composed of plate glass windows five feet square, through the center of which the conductor passes. Various arrangements of extra insulation around the conductor have been tried. Our experience seems to show that the best arrangements of plate glass windows is to use a bare conductor of large diameter and leave as large an opening around the conductor as climatic conditions permit. The window should be so protected that rain may not run over the surface of the glass.

10. We are using electrolytic lightning arresters at each end of the main line. Having had no lightning, we have had no experience with them as lightning arresters. We have operated one circuit without lightning arresters at either end for some time. Our experience has shown that they can not absorb much energy without being damaged and therefore their critical voltage must be higher than any dynamic voltage that may ever occur upon the system.

11. We have had no sleet, nor any trouble from wind since the line was finished.

12. There is no appreciable corona effect on the main line. Probably no very great increase in voltage would produce corona on the branch line No. 6 copper wire. No part of the line is over 2000 feet elevation above sea level.

13. The telephone line is strung on the towers. In regular spans it is supported by three hangers which are carried by a grounded messenger cable. Drainage coils consisting of the 2200-volt winding of a two kw. transformer with the center point grounded are used at both ends and in the center of the line. These reduce the voltage to ground of the telephone line to a very low value, probably less than 100 volts. This obviates the necessity for especially high insulation and reduces the noise due to unequal leakage. Highly insulated repeating coils are used where connections are made to telephones at which it is impossible to secure adequate insulation to ground of the person using the instrument. The telephone line is transposed at every tower where the towers are evenly spaced. Where the tower spacing is uneven the distance between transpositions is made as even as possible. The service obtained from this line is very satisfactory and is not more than momentarily interrupted by disturbances on the power line.

14. The only difficulty in maintaining satisfactory voltage regulation is at times when changes in load amounting to a large percentage of the total occur suddenly.

15. Steel towers whose general dimensions are given in Fig. 1 are used. Foundations suitable to the character of the ground must be used. Piles are used in very soft ground, cut off below the ground water level. The tower footing is attached to the top of the pile. All the tower footings are set in concrete. There have been no signs of corrosion in two years.

16. The system has been operated at 100,000 volts since November 1, 1909.

Our experience indicates that the following points should receive special attention when planning an extra high tension, long distance transmission system:

Generator capacity to handle the charging current.

Provision for the proper control of the system under all possible emergency conditions.

If delta operation is contemplated, insulation should be provided that will safety withstand the full delta voltage. The insulation should be of a character especially adapted to withstand transient voltage strains considerably in excess of the delta voltage.

THE BRIQUETTING OF LIGNITE.

The results of the investigations into the briquetting of lignite have just been published by the Bureau of Mines in Bulletin No. 14. Charles L. Wright, who conducted the tests and who is author of the bulletin, declares that enough testing has been done to indicate that some American lignites equal German lignites in fuel value and can probably be made into briquets on a commercial scale without the use of binding materials.

Three samples of lignites, one from Texas, one from North Dakota, and one from California, were made into satisfactory briquets without the addition of a binder. It was proved that some lignites after having slacked by exposure can be made into briquets without the use of binding material, notwithstanding a general opinion that this could not be done. Cohesion and weathering tests demonstrated that good briquets endure handling and resist weathering much better than the lignite from which they are made.

The tests described apparently show that the cost of briquetting run-of-mine lignites with a German plant, which was used, would be from $1.35 to $1.75 per ton, according to the location of the plant. The cost per ton of briquets, loaded on cars, from a briquet plant at the mine would be, in Texas, $2.51; in North Dakota, $3.53; and in California, $5.24.

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CONTENTS

Precipitation and Altitude in the Sierras 23
By Charles H. Lee.

New Specifications for Rubber-Covered Wire 29

Weather-Proofed Electric Cable for China 30

Steam Shovel for Ditching 31

The Cost of Concrete at Panama 31

Properties and Uses of Douglas Fir 32

Telegraph Extension in China 34

Transmission System of the Great Western Power Co. 34
By J. P. Jollyman.

The Briquetting of Lignite 35

Editorial 36
- P. A. Y. E. Cars.
- Western Enterprise.
- Watershed Data.
- Workman's Accident Compensation.

Personals 38

Trade Notes 38

Patents 39
- Hydraulic Dredging Apparatus.
- High Tension Discharge Apparatus.
- Turbine Water Wheel.
- Driving Dynamos from Variable and Non-Variable Sources of Power.
- Combined Bevel, Protractor and Rule.

Industrial 40
- Pneumatically Operated Disconnecting Switches.
- Lighting a Factory Location.
- General Electric Company's New Catalogues.

News Notes 42

P. A. Y. E. Cars

In the enterprising little city of Missoula, Montana, there have been in successful operation for over a year the new and up-to-date pay-as-you-enter cars. For the traffic of this city of 15,000, under this new and admirable system, but one operator is necessary on each car. The new equipment has proven thoroughly practicable and in its operation has been found rapid, convenient and void of confusion. The remarkably few accidents met with in this system should command the careful consideration of other municipal corporations entertaining a change from the old style of operation.

Western Enterprise

The spirit of enterprise and aggressiveness has ever been synonomous with the spirit of the West. Today we see the budding young hamlet which tomorrow will make the thriving city. The phenomenal growth of Los Angeles, the San Francisco bay cities, Portland, Seattle, Tacoma and Spokane came as no surprise to the careful observer. Their citizens were imbued with the brave optimistic boosting spirit known only on the western slope of the Rockies. The careful observer of today can predict with almost scientific accuracy the coming cities of tomorrow.

It is true that first of all a community in order to have a future must have a legitimate excuse for existence such as climate, natural resources, future natural commercial opportunities, richness of soil of surrounding country either predominating in some one feature or possessing many in combination. But this alone is not sufficient. Cities in the past have failed and ever remained stunted in their growth when every natural blessing seemed to favor them. It is easy to find the cause. A lack of self-sacrifice on the part of its citizens will do more to kill a community than any other single feature of its civic life.

The Pacific Coast States fairly vibrate with the young life and fostering spirit of its cities. From a financial point of view, one of two things usually aid in transforming a town into a city. It must either have manufacturies within sufficient for self support or the immediate surrounding country must be under such a high state of development as to need a substantial distributing point. Like anything else in life the good things only come by earnest unceasing effort. Manufacturies come to a place through individual effort. Material inducements offered to bona fide prospective manufacturies have done more to locate industries in young cities than any one thing.

Medford, Oregon, can be cited as one instance where public spirited enterprise is shown by one of its public service corporations. H. C. Stoddard, manager of the Rogue River Electric Company offers in the name of his company free electric power for one year to any manufacturing concern establishing a plant there which does not compete with any concern already established. This example is worthy of imitation in our other young progressive cities in the west. It means self-sacrifice today, but tomorrow the reward will be certain!

Watershed Data

We present in this issue a careful compilation of data showing the relation between precipitation and elevation in the Owens River country. In our issue of July 1st we printed an abstract of a paper by Professor D. W. Mead of Wisconsin University on the "Flow of Streams and the Factors That Modify It." with special reference to Wisconsin conditions.

A systematic study of stream flow will eventually solve many of the problems now live issues before the American people, such as the value of forests for increasing or equalizing stream flow and the application of storage not only for the prevention of floods but for the promotion of the uniform flow required in navigation and essential for power and watershed purposes.

It is with considerable pride that we note from time to time the careful collecting of data concerning our great natural watersheds, both by government and private enterprise. As in the swinging of the magnetic pole in its pendulum vibrations, we find repetitions of declination every series of years, so there seems to be in all natural phenomena a periodic return of conditions from time to time. Since the forces are so variable which bring about our climatic conditions that it is almost impossible to foretell with exactness for any given season the amount of precipitation in any one locality. we are fortunate if we can determine it within reasonable limits.

By careful comparison of data collected from time to time it is surprising with what degree of exactness the limit can be determined. So it is as years go by and carefully compiled data continues to heap up from the study of our great watersheds, we shall more and more be able to arrive at exact definite conclusions as to the laws governing precipitation, run-off and evaporation which will prove of invaluable service to mankind. Thus we shall be enabled to arrive at definite factors of safety to use in conduit design as well as in the design of diversion works and spillways. As most of the great watersheds in some of our newer States, such as Montana and Wyoming, lie within the national forests, it is gratifying to note that the forestry officials are gathering, with considerable exactness, data on the monthly and even daily flow of the smaller streams. These have in a measure been necessarily overlooked by the U. S. Geological Survey in their series of water compilations. Such data have have already proved of inestimable value to farmers in one of the great fruit valleys of Montana. They have given definite ideas as to proper design for storage reservoirs and ideas as to the factors of safety to be allowed in designing spillways and diversion dams to take care of unusual flow and prevent disaster.

Workman's Accident Compensation

On October first of this year the workman's compensation act passed by the last Legislature of the State of Washington, will go into effect in that commonwealth. The details of this law appeared in our issue of July first.

From every point of view the question of workman's compensation in event of accident while employed in any one of the industries is, perhaps, one of the most vital now before the employer and his men. The daily press is filled with accounts of the mammoth lawsuits brought by the employed against the employer for injuries received while at work. The suit eventually goes to trial. We read of the impression made upon the jury by the bandaged appearance of the injured when he is brought into court or of their tear-stained eyes when they look upon the pretty, helpless widow and her children. A large award is made, and yet upon inquiry we find that the injured, when paid, is as financially helpless as before.

Upon investigation we are informed that the heavy legal expenses in fighting the case have left but the widow's mite, although several thousand dollars should be at her disposal. The question then eventually resolves itself to this: if it is just and proper that compensation should be paid by the employer to his employed in event of injuries sustained while at work, a proper and speedy remedy should be at hand.

Similar to all other forms of risk, either insurance with private companies organized for such purposes should be required by law and maintained jointly by the employed and his employer in a just and fair distribution of the burden, or the government should enact proper regulations and make just awards. The funds for this purpose should be acquired by monthly or annual premiums paid in by the employed and the employer in each craft in amounts shown to be necessary according to statistics compiled from long periods of time.

The question of dealing out justice in the case of accident incurred at work in the industries and the amount of responsibility therefor which should justly rest upon the employed or his employer is one of the most delicate to be determined in any given case. Unquestionably many accidents occur that are absolutely and wholly to be laid against improper and unsafe equipment, but on the other hand it is impossible to make any workshop in the great industries absolutely "fool proof." Then again many accidents occur which are absolutely unforseen and cannot be avoided, no matter what wisdom in design the employer may show in planning the equipment or the care exercised by the workman in going about his daily tasks. But such acts of Providence should be provided for somewhere and somehow in this uncertain world.

It should make us cringe to note the many just cases in which awards have been made, and yet, when the inventory is taken of what is left the widow and her children, find the lawyer and expenses incident to his work have absorbed nearly the whole, while the employer has also spent an equal amount in attempting to defend the case. From the employer's point of view, too, the thousands of dollars annually spent in successfully defending suits, would, if this enormous expense be done away with by an examining commission, go a long way towards establishing a sinking fund to take care of genuine cases of liability.

In New York and many of the other great cities of the world, have been established Museums of Safety. These have done much towards the prevention of accidents. For those that are unavoidable may the near future evolve some equitable, speedy and sure method by which the sufferer or his widow may find relief.

PERSONALS.

M. R. Cahill of the Diehl Manufacturing Company is spending his vacation on the Pacific Coast.

Rudolph W. Van Norden, consulting engineer, San Francisco, is investigating an irrigation project near Stockton, Cal.

Ralph D. Mershon, a prominent consulting engineer of New York, was a visitor in San Francisco during the past week.

F. J. Lepreaux of the Edison Manufacturing Company, manufacturers of the Edison-Lalande battery, is at Los Angeles.

Arnold Pfau, hydraulic engineer with the Allis-Chalmers Company's factory, arrived at their San Francisco office last Saturday.

J. W. White, of the Fort Wayne sales department, has just returned to his San Francisco office after a flying trip to Los Angeles.

Cas Gilson, formerly salesman with the Pacific States Electric Company, has opened the Oak Electric Supply Company at Oakland, Cal.

H. R. Noack, manager of Pierson, Roeding & Co., after recent extensive trips to the East and Middle West, is now on his homeward journey.

Isaac W. Anderson, of Tacoma, Wash., who is interested in electric railway lines in the district tributary to Walla Walla, arrived at San Francisco last week.

Frank W. Hall, manager of the Philadelphia office of the Sprague Electric Works, has been appointed manager of hoist sales and after July 15, 1911, will be at the New York office.

E. R. Hill, of the firm of Gibbs & Hill, the New York electrical engineers who have had charge of the Pennsylvania Railroad tunnel work, was at San Francisco last week.

A. C. Sprout, electrical engineer, will spend most of the summer in Siskiyou County on electrical construction work for the Siskiyou Light and Power Company. About $30,000 worth of construction material has just been purchased for use on the system.

R. D. Holabird, president of the Holabird-Reynolds Company, has returned to his San Francisco store after an Eastern trip of two months. He spent ten days at Seattle where he has just doubled the space occupied by the branch on First avenue South, in that city.

H. H. Noble, president of the Northern California Power Company, has just returned to his San Francisco office after an inspection of the construction work in progress at the Coleman power station and elsewhere. He was accompanied on the trip by Edward Whaley, the auditor and purchasing agent of the corporation.

Alfred H. Coates, president of the Colonial Electrical Agency Company, of San Francisco, Cal., expects to leave early in July on his annual eastern trip. He will spend some time in Warren, Ohio, at the headquarters of the Colonial Electric Company and the Economy Electric Company, both of which concerns are represented on the Pacific Coast by Mr. Coates' company.

Bion J. Arnold, consulting electrical engineer, and Past President of the American Institute of Electrical Engineers, has of late been engaged in professional work in Los Angeles. Mr. Arnold has been employed by many of the large cities, including Chicago and Los Angeles, upon investigations of their electric traction problems. In fact, the Board of Supervisors of San Francisco have been considering the advisability of securing his advice with a view toward bettering the local street railway service.

James A. Clifford, manager of the Baltimore office of the Sprague Electric Works, has been appointed manager of the Philadelphia office and took charge there on July 1, 1911. The Baltimore office will be continued as in the past under Mr. Clifford's direction, but as subsidiary to the Philadelphia office and with Henry S. Patterson in charge.

C. L. Cory, consulting engineer, accompanied by Mrs. Cory, left San Francisco last week via boat for the Pacific Northwest. Professor Cory has been retained by Mr. Huntington of the Washington Water Power Company to make an independent valuation of the company's holdings. Upon completing his work at Spokane he will take a pleasure and business trip East, returning to Berkeley in about six weeks

V. H. Greisser, electrical engineer of the Washington Water Power Company, of Spokane, Wash., has just returned from a five weeks' trip in the East. The prime purpose of his visit was to select the switching apparatus for the new 90,000 h.p. hydroelectric plant which this company is building at Long Lake, thirty miles from Spokane. This plant will include all features necessary to make it one of the most complete installations from an operating standpoint, that exist in the country. While in the East Mr. Greisser visited power plants and transmission systems at Chicago, Niagara and in the Carolinas.

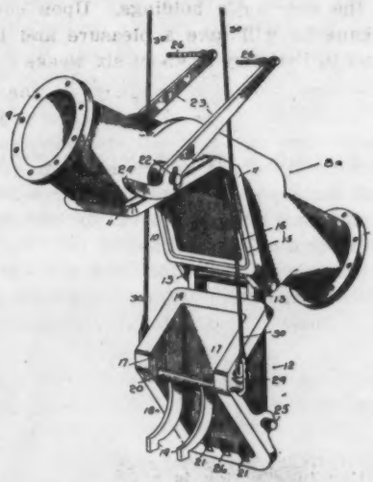
James H. Wise, hydraulic engineer with F. G. Baum & Co., has been appointed assistant general manager of the Pacific Gas and Electric Company of San Francisco. He assumed his new duties on July 1st, and will oversee the construction and extension of a number of new steam and hydroelectric plants to be added to the company's system. Mr. Wise entered the employ of the Pacific Gas and Electric Company a year after his graduation in 1903 with honors from the mining department of the University of California, the interim having been spent in teaching mathematics at the California School of Mechanical Arts. Serving first as instrument man and later in charge of field work, he was soon made assistant to Frank G. Baum. When the latter resigned as hydraulic and civil engineer, Mr. Wise succeeded to the position, which he resigned early in 1910, to join forces with Frank G. Baum & Co., being retained as consulting engineer with the Pacific Gas and Electric Company.

TRADE NOTES.

Agutter-Griswold Company of Seattle, Wash., announce that they have given up the construction end of their business and will devote their attention to the manufacture of switches, switchboards, panelboards, steel cabinets, mitering panels, etc. The completion on June 1st of their new factory, supplied throughout with the best of machinery and equipment, puts them in position to better handle their largely increased manufacturing business and makes it possible at this time to make this change.

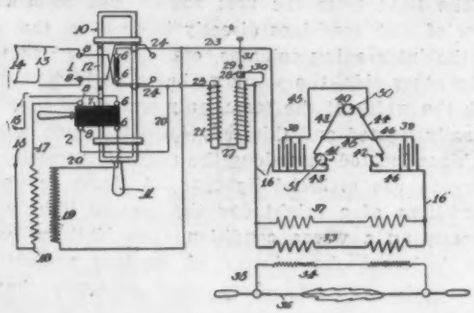
PATENTS

996,237. Hydraulic Dredging Apparatus. Fred H. Gridley, Long Beach, Cal., assignor of forty-five one-hundredths to North American Dredging Co. of Nevada, Los Angeles, Cal. A stone arrester for hydraulic dredges comprising in combination, a housing adapted to be connected into and form part



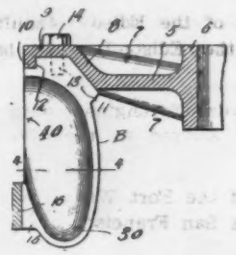
of the suction pipe of said dredge, said housing having a port therein, a grid adjacent to said port, a closure for said port, said closure normally held to place by fluid pressure external to said pipe but adapted to move from said normal position when the excess of external pressure is removed.

996,280. High-Tension Discharge Apparatus. Edgar J. Rose, Los Angeles, Cal. In a high-tension discharge apparatus, a charging circuit comprising means for connection of supply current, a self-induction means, and a circuit controller, electromagnetic means for operating said circuit controller comprising a coil, an armature controlled thereby and operating the circuit controller, and a spring acting on the armature in



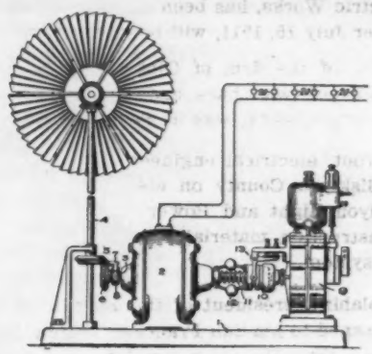
opposition to the coil, the time period of the electro-magnetic means being shorter than the time period of the charging circuit, so that at each operation the electro-magnetic operating means restores the normal condition before the discharge of the self-induction coil ceases, and a discharge circuit including a condenser and high tension transformer connected to said circuit controller.

996,525. Turbine Water-Wheel. Sherrod W. Reece, Portland, Ore. In a turbine water wheel, a supporting plate or spider having an inclined flange portion from the upper edge of which a horizontal flange extends in an outward direction, said flange being provided adjacent to its outer edge with a downwardly extending rim co-operating with the horizontal flange and with the inclined flange portion to form an annular recess, in combination with bucket members having angular reinforcements forming head pieces fitting in said recess and



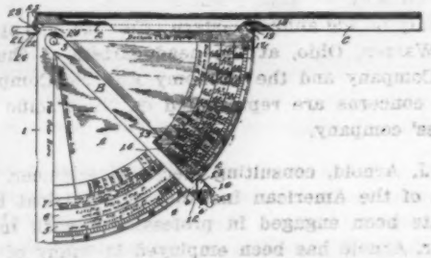
provided adjacent to their outer edges with notches for the reception of the rim and with threaded sockets, and cap screws engaging said sockets through the flange of the spider to draw the reinforced portions of the buckets into the annular recess where said reinforced portions will be securely seated.

996,334. Driving Dynamos from Variable and Non-Variable Sources of Power. Caryl D. Haskins, Schenectady, N. Y., assignor to General Electric Company. The combination with a generator, of means for maintaining a fairly constant potential on said generator comprising a fluctuating



source of power, a steady source of power, and means for coupling said generator to the latter source when the former falls below a critical speed and for automatically uncoupling the steady source when the fluctuating source exceeds the critical speed.

996,591 Combined Bevel, Protractor, and Rule. Joseph La Follette, Portland, Ore. An instrument of the class described comprising a scale bearing plate having notches adjacent to two of its corners, a rule having a longitudinal groove into which

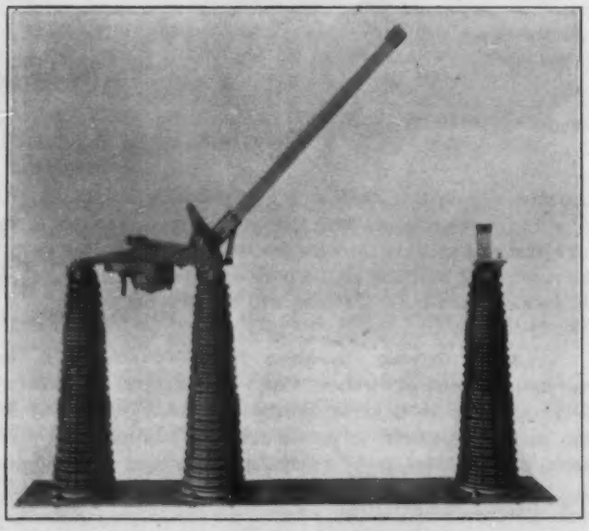


one edge of the plate fits, a shoulder in one end of the groove for engaging one of the notches on the plate, a pivoted locking lever on the rule having means for engaging in the other notch of the plate to hold the rule detachably in place.

INDUSTRIAL

PNEUMATICALLY OPERATED DISCONNECTING SWITCHES.

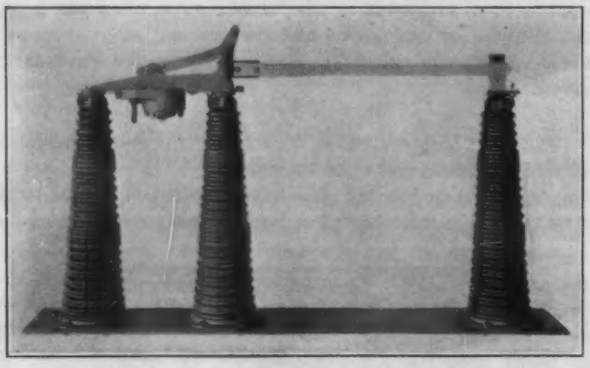
Bus isolating or disconnecting switches are usually opened or closed by means of a wooden rod, having at one end a hook to engage with the hole in the switch blade. Ordinarily this is quite satisfactory.



Pneumatically Operated 110,000 Volt Switch (open).

In many cases, however, to simplify the wiring layout, to save in length of large cables, for convenience, or for safety, it is advisable to locate the disconnecting switches in a position where they cannot be easily reached by the station operator. It is in such connection that pneumatically operated disconnecting switches find useful application.

The switches of this type, made by the General Electric Company, are clearly shown in the accompanying illustrations. They can be located at any height and can be controlled by an air control valve or pull button switch located at the switchboard or other convenient point.



Pneumatically Operated 110,000 Volt Switch (closed).

These switches are simple and substantial in construction, being similar to the hand operated switches and introduce no complications in wiring. They are mounted on post type insulators fastened to steel bases, the insulators varying in size according to the voltage.

The switches are made up in single pole, single throw form only, but can be opened and closed singly or any number of poles can be operated in unison. Also, one or more sets can be operated simultaneously by a single air control valve or pull button switch. This gives great flexibility of operation.

Pneumatically operated disconnecting switches are especially adapted for use in stations employing air operated oil switches, but can, of course, be used in any case where an air supply is available.

When a pull button switch is used to operate the disconnecting switch the valves in the air connections to the diaphragm are operated electrically—usually from the lighting or exciter circuit. These switches are made in voltages from 35,000 to 110,000 and for currents of from 100 to 300 amperes.

LIGHTING A FACTORY LOCATION.

Among all the reports on lighting installations that have appeared in the past months, there are comparatively few that deal with the question of lighting the rougher locations such as machine shops, mills, factories and the like, due to the fact, no doubt, that very little work has been done along this line or that those conducting the work have little time to report on it.

It is the object of this article to describe the manner in which a very dark machine shop was lighted, by a very simple but effective method and one that has given entire satisfaction to all concerned.

The location in question is a typical inside factory one, being an aisle 40 feet wide situated between two other aisles of a slightly greater width, and separated from them only by the columns that carry the roof. Four hundred feet of this aisle is used for general machine work, mostly lathe work. The height of ceiling is 12 feet. The ceiling is formed by the floor above, of wood (2 by 8 in.) and is divided into bays 40 by 18 ft. by the supporting girders. A crane runs the entire length of the aisle with a clearance of only 13 in. above the hoist.

The natural lighting comes from the aisles on each side, one having a row of windows occupying the entire outside wall, the other making use of sky lights and a row of windows just under the roof at a height of about 50 feet from the floor. The light from the first source was mostly cut off by a row of high machines directly in front of the windows and by the intervening columns, crane girders and the like. From the other side, the windows being so high in comparison with the width of the room, only a narrow strip of floor was directly lighted and this only imperfectly on account of the machines located just along the edge of the aisle. It was necessary to use artificial light at all times as under the best conditions of a bright day the natural light was very dim, presenting a worse condition than if there had been absolute darkness, the mixture of daylight necessitating a higher artificial intensity than would otherwise have been necessary.

Formerly, clusters of carbon lamps scattered here and there, formed the general lighting scheme, each machine being furnished with one or more extension lamps which were moved from place to place as the operator required. Not only was the light insufficient but the constant transfer of lamps with the consequent breakage and damage to the cord made the maintenance cost so high and reduced the efficiency of the workmen, both in quality and quantity, to such an extent that some change was made necessary. It was impossible to keep good men on account of the inconvenience and unpleasantness of the location.

The small clearance over the crane together with the low ceiling excluded all types of lamps except the incandescent. Carbon lamps in sufficient numbers would have required an excessive current consumption so that tungsten units were

selected as being the most applicable. At the time there was some doubt as to the advisability of using tungsten lamps as the floor above was used for machining heavy castings and the constant dropping of these, it was feared, would cause a large breakage of lamps, they being of the old fuse type.

In order to determine the exact effect that this would have on the life of the lamps, two bays were each equipped with eight 100 watt, clear tungsten lamps, with Intensive glass reflectors, mounted directly on the ceiling with one inch of free cord between the rosette and the socket. The lamps being in two rows, of four lamps each per day, thus making the spacing distance 8 by 10 ft. with a power consumption of 1.25 watts per square foot of floor space. The switching was arranged so that four lamps could be operated in a group, thus permitting small areas to be lighted without waste. After several weeks operation the breakage was found to be only slight. With a replacement by the Westinghouse Wire-Type lamp the breakage has disappeared regardless of the vibration due to cranes and to the dropping of heavy weights on the floor above.

Illuminated Factory Interior.

The illumination was uniform and of sufficient intensity for the class of work done there, and the place was transformed from a gloomy into a cheerful location. The spirit of the men improved as was shown by the quality of the work turned out. The floor was kept cleaner and the whole appearance of the place improved. In fact so satisfactory was the result that the entire 25 bays were similarly equipped. All extension lamps have been removed except where it is necessary to see into deep work or under machines. For this purpose plug boxes have been placed at convenient places and the extension lines are used only when necessary, with the result that the general lighting scheme is never interfered with and the room is free from the mass of cord that generaly characterizes like locations.

This system has been in service for well over a year and careful records have shown that the cost is reasonable and that the saving in quality of work and the ability to keep good men has more than repaid the original expense.

The accompanying photograph, taken at night without any light except from the ordinary source, shows the location and gives some idea of the satisfactory character of the illumination. All parts of the room are sufficiently lighted to permit of work being done with equal ease at any point. Tests showed that the average intensity on the horizontal plane averaged 2.5 foot-candles, with a minimum of 1.6 foot-candles at the extreme edge of the room.

GENERAL ELECTRIC COMPANY'S NEW CATALOGUES.

In Bulletin No. 4818, issued by the General Electric Company, are described flange couplings and flexible couplings.

The General Electric Company's Bulletin No. 4829 illustrates and describes electric locomotives built for both standard and narrow gauge, in various styles.

The General Electric Company has recently issued Bulletin No. 4846, which contains such information as will enable the prospective customer to select intelligently the switchboard panels best suited to his needs.

Bulletin No. 4852, just issued by the General Electric Company, contains a description of a standard 50-ton locomotive and its equipment, and a statement of features of construction.

The General Electric Company has developed a line of commutating pole generators in which commutating trouble is eliminated. These generators are built for slow and moderate speeds, range in capacity from 20 to 150 kw. and are wound for 125, 250 and 575 volts. They may be equipped with sliding base or with belt tightener, as desired. They are described in Bulletin No. 4832, which contains also a table giving dimensions.

Catalogue K from the Ohio Brass Company, of Mansfield, Ohio, is devoted to Ohio valves and steam specialties, special attention being given to their water gauge and their pressure regulating valve, a device which automatically delivers steam or air at any desired uniform pressure lower than that supplied to the valve. In connection with this is a valuable chart for determining the proper size of regulating valve for a given service.

The General Electric Company has just issued a publication describing another of its flow meters, which, in this instance, is designed for measuring the flow of steam. Two forms of the steam flow meters are manufactured; one for recording and the other for merely indicating the flow. This meter resembles somewhat the air and water meters manufactured by this company, and is fully illustrated and described in this publication, which is No. 4836.

Bulletin No. 4851, just issued by the General Electric Company, is an attractive publication containing data relative to the use of electricity in the service of steam roads. The publication comprises 48 pages which illustrate and describe both station and road equipment of the New York Central & Hudson River Railroad; the Detroit Tunnel of the Michigan Central Road; the Cascade Tunnel of the Great Northern Railway; the equipment of the Baltimore & Ohio Railway; the West Jersey & Seashore, the West Shore Railroad, etc.

The General Electric Company's line of belt driven alternating current generators, known as Form B generators, are described in Bulletin No. 4847, recently issued by that company. These generators are built in capacities ranging from 50 to 200 kw., and are adapted for three-phase or two-phase winding without change except in the armature coils and terminal blocks, the exciters and all accessories being the same for both. Designs have been made for 240, 480, 600, 1150 and 2300 volts.

The General Electric Company has recently issued Bulletin No. 4848, describing its new combination ammeter and voltmeter. This instrument is enclosed in a dust-proof and moisture-proof aluminum case, and is designed to withstand the constant vibration and exposure incident to service on electric vehicles. The publication contains dimension and connection diagrams, and illustrations in actual size of the scales.

NEWS NOTES

FINANCIAL.

ELMA, WASH.—The council has decided to vote municipal bonds for $10,000 for the construction of a water system.

PORTLAND, ORE.—The Clatskanio Electric Light & Power Company has increased its capital stock from $25,000 to $75,000.

INDEPENDENCE, ORE.—A $25,000 bond issue for a water system has been decided upon. Work on the new water system is to begin at once.

ALAMEDA, CAL.—The City Council held a special session last week to consider the items for the proposed bond issue. The council decided to include $125,000 for the electric light plant, including $75,000 for general betterments $25,000 for a new building and $15,000 for new wire, other smaller items taking up the additional $10,000. The plant is now carrying a 40 per cent overload.

BERKELEY, CAL.—On the strength of a report presented by City Expert C. L. Cory on the income of the electric light company, the Berkeley City Council failed to reduce the rate from 9 to 7c per kw. hour. John A. Britton, representing the company, stated if the rate was cut to 8c that the profits of the corporation in Berkeley would be reduced $24,000 a year, while the 7c rate would mean a difference of $60,000 a year. Cory's estimate placed the value of the plant at $576,886.82 and gave the net revenue of the plant at $45,115.37, allowing for depreciation at 7.98 per cent annually. His report was compiled by comparing the expenditure and revenue of the corporation for the past three years. Mr. Britton asserted that the company was compelled to charge the 9c rate in order to get a revenue on the investment, that it was exceedingly low when compared with that of other cities.

INCORPORATIONS.

OAKESDALE, WASH.—The Oakesdale Home Telephone Company, capital $10,000, has been incorporated by C. G. Mead and A. G. Woodward.

SAN FRANCISCO, CAL.—The Mokelumne River Power Company has been incorporated with a capital stock of $3,000,000, by L. Brown, A. H. Elliott, A. M. Sherman, M. E. Logan and G. C. Elliott.

HOOD RIVER, ORE.—Articles of incorporation of the Hydroelectric Company of Hood River have been recorded in the county clerk's office. The incorporators are W. Evans, J. Watt and H. J. Jackson. Capital stock $250,000.

RIVERSIDE, CAL.—The Vernon Park Water Company has been incorporated with a capital stock of $75,000 with $500 subscribed. The directors are A. H. Bailey, H. C. Harding, H. V. Wall, B. J. Brien and C. E. Lewis, all of Los Angeles.

TRANSMISSION.

LACROSSE, WASH.—Representatives of the Washington Water Power Company are here with a view of extending their lighting and power systems to this city from Colfax.

PORT ORCHARD, WASH.—The Bremerton & Charleston Light & Fuel Company has petitioned the county commissioners for a franchise to furnish electric current for lighting and other purposes on certain streets and roads.

PROSSER, WASH.—The Pacific Power & Light Company has started work on the expenditure of $15,000 for improving its local power plant. Three new transformers of 66,000 volts and one 600 kilowatt generator will be installed.

WALLA WALLA, WASH.—R. E. Downie & Co., Seattle, has been awarded the contract for furnishing a quantity of 50-ft. poles for the Pacific Power & Light Company's power line under construction from this place to Dayton, Wash.

KLAMATH FALLS, ORE.—Judge William Colvig of Medford, representing the Rogue River Electric Power Company, has arrived in Klamath Falls and has submitted to the city council a proposition to furnish this city with electric power.

VALLEJO, CAL.—The government has asked for bids to cover the cost of pipe and boiler construction for a new power house, which will represent an expenditure of more than $100,000. The figures are to be opened in Washington on July 8th.

EUREKA, CAL.—Since the Western States Gas and Electric Company has taken over the holdings of the Fortuna and Ferndale lighting companies, improvements are to be made throughout the valley. The substation at Loleta will be moved further up the river.

PASCO, WASH.—Vice-President Grenier of the Pacific Power & Light Company will shortly award the contract for constructing the first unit of the switching station for that company. Plans for the first unit which will cost $85,000 are on file at the Portland and local office.

WOODLAND, WASH.—Preliminary surveys are being made to establish the water line, etc., at Tum Tum canyon, 30 miles above this place, for a company which will erect a power dam 150 ft. high to generate 3000 h.p. Work will start this summer and power and light will be distributed to adjoining towns.

ILLUMINATION.

SANTA ANA, CAL.—The Board of Supervisors will receive sealed bids up to July 6 for furnishing electric lights on certain streets in Garden Grove Lighting District.

NEWPORT, WASH.—The Northern Idaho & Montesano Power Company has been granted a franchise for the construction of an electric lighting system for the village of Priest River, Wash.

TRANSPORTATION.

WOODLAND, CAL.—The City Trustees have granted the Vallejo & Northern Railroad a franchise on Main street from the eastern to the western limits.

BISHOP, CAL.—Grading began last week on the Owens Valley Electric Railway connecting Bishop with the Southern Pacific at Laws, with proposed extensions to neighboring places.

CHICO, CAL.—The Board of Trustees has passed an ordinance granting the Northern Electric Railway Company, a franchise to operate a street railway over certain streets in Chico.

SAN BERNARDINO, CAL.—W. G. Kerckhoff has entered into negotiations with the local Chamber of Commerce for the construction of an electric line from San Bernardino to Upland. He asked that steps be taken to secure right of way for the line.

EUGENE, ORE.—Deeds for the right of way for several miles of the electric railway to be built between Eugene and Corvallis by the Portland, Eugene & Eastern Railway, have been filed for record with the county clerk. Construction will begin before December 1 next.

OAKLAND, CAL.—Work has begun by the Key Route on its line to Richmond, which branches off its local lines at 54th and Adeline streets. The track is practically all completed and poles to carry the trolley wires are being set up. The work should be completed within a few months and the line in operation before the end of the present year.

OAKLAND, CAL.—The first electric train of the Southern Pacific Company ran into Oakland last week on a tryout trip. In Alameda the first run of an electric train was made over the north side Lincoln avenue line to High street. Both experimental trips were successful, and according to the railroad officials it will be a matter of only a few weeks till the regular electric service is established on the new Alameda loop, which swings down to the east end of the island.

OAKLAND, CAL.—Pursuant to plans formed recently by the management of the Oakland and Antioch Railway Company and the financial backers of the concern in New York and Boston, a corps of engineers is now surveying a new line for the road between Walnut Creek and Oakland which will include a new inter-county tunnel. The tunnel will be two miles in length, according to one of the surveys, and longer according to another. Three schemes of this kind are being laid out.

OAKLAND, CAL.—Plans for a grand central depot for the Oakland Traction and Key Route and Oakland and Antioch lines in the business center of Oakland are being worked out by the engineers and expert traction men of the United Properties Company. It is probable that this depot and passenger distributing station will be established within a year and it will occupy the building now known as the Oakland Produce Exchange, between 12th and 11th, and Webster and Harrison streets. That the Key Route management will take steps at once to have its franchise so amended, if amendment be necessary, to permit running two-car trains on the main lines of the Oakland Tranction Company, is generally understood and the directors of the Oakland Chamber of Commerce are considering the advisability of supporting the movement.

SAN FRANCISCO, CAL.—There has been filed with the Supervisors an application for a franchise for an underground railway to extend from the ferry depot at the foot of Market street to Golden Gate Park. The project is said to have the backing of one of the greatest English traction companies. The real applicant for the franchise which will be asked for on Monday through a local agent is the British Electric Traction Company, which controls many of the biggest street railway systems of England and Australia. The company is said to be willing to put $15,000,000 into the work of construction at once and, if the franchise can be secured, to begin work without delay. It is estimated by the engineers who have prepared preliminary plans for the English concern that the subway can be completed within two and a half years. Thomas King Ewer, now in this city, is the local representative of the British Electric Traction Company.

TELEPHONE AND TELEGRAPH.

CORNING, CAL.—The Board of Trustees has passed an ordinance granting the right of erecting and maintaining a telephone system, throughout the city of Corning.

CENTRAL POINT, ORE.—The bid of the Jacobson-Bade Company for $12,000 for the extension of the water system has been accepted by the council.

NAPA, CAL.—W. M. Lyons, has made application to the Board of Supervisors for a franchise for a period of 50 years, to operate telephone lines along the public roads of Napa county. Sealed bids will be received by the clerk of the Board of Supervisors up to July 11, 1911, for the sale of said franchise.

FULLERTON, CAL.—The Board of Supervisors has granted the application of the Standard Oil Company for permission to lay pipe and telephone wires across the county roads at their right of way.

PETALUMA, CAL.—W. D. Thomas is negotiating with I. Maggetti, Messrs. Berri, Camboni and many other farmers in the district near Marshall, for the installation of a rural telephone line from Marshall to Petaluma.

WELLS, NEV.—The request of C. G. Winters asking for a permit to set poles and build a telephone line from the State line of Nevada and Idaho, commencing at Rattlesnake springs on Wilkin's island, has been granted.

WATERWORKS.

LIVINGSTON, CAL.—Constable J. A. Watson has been granted permission by the Board of Supervisors to lay pipes under the streets of Livingston for the purpose of maintaining a water system.

ORANGE, CAL.—The Board of Supervisors has passed an ordinance granting a franchise to Santos Moraga to construct a water system for supplying Richfield for domestic and other purposes for fifty years.

HOQUIAM, WASH.—Portland capitalists are considering a plan to bring water from Lake Quinault to this city, furnishing both Hoquiam and Aberdeen. J. D. Moughmer, former city engineer, is one of the promoters.

SAN FRANCISCO, CAL.—The Board of Public Works has been authorized to go ahead with the repair and enlargement of the water supply system at the Relief Home, the cost of which was estimated at $16,000.

OAKLAND, CAL.—The Peoples Water Company announces that the corporation will commence the laying of 2200 feet of 9-inch water mains in the Hopkins street district in the near future for the purpose of increasing the water supply of the district.

WATSONVILLE, CAL.—At the next meeting of the Aldermen the city attorney will present a prepared ordinance calling for a special election at which the people will be asked to incur an indebtedness of $110,000 for the purpose of constructing an entirely new water system.

BERKELEY, CAL.—The City Council has set the minimum water rate at $1.25 and made a fire hydrant rate of $3, and a sprinkling rate of 30c in spite of a strenuous protest on the part of Engineer Wilhelm of the Peoples Water Company. The water company was represented by Wilhelm and Attorney Edward Engs, both of whom declared the former minimum rate of $1.50 was as low as the company could operate under.

SAN FRANCISCO, CAL.—To avert a water famine in the peninsula in the near future, 15 representatives of water companies operating in San Mateo county held a conference in the office of Attorney Milton J. Green, in the Mills building. Although invited to participate no representative of the Spring Valley Company was present. Capt. H. N. Royden of the Peninsula Water Company, which operates in San Mateo and Burlingame, presided. A committee consisting of the chairman and A. T. Green will take up the matter with the board of governors of the San Mateo County Development Board. Resolutions were passed and the assertion was made that a certain and adequate present and future water supply for San Mateo county must be obtained; that it is deemed advisable on that account to merge the various water companies operating in the northern part of the county; that the opportunity of securing a proper supply will be lost if Spring Valley sells its plant to San Francisco; that the company to be formed should negotiate with Spring Valley for a fixed and definite supply of water for the present and future.

INDEX TO ADVERTISEMENTS

A

Allis-Chalmers Co. ... 2
Milwaukee, Wis.
San Francisco, Jackson Bldg., Second & Natoma
Los Angeles, 129-131 E. Fifth.
Portland, 92 First.
Seattle, 115 Jackson.

Aluminum Co. of America ... 4
Pittsburg, Pa.
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electric Bldg.
Seattle, Colman Bldg.

American Circular Loom Co. ...
Boston, 45 Milk.
San Francisco, 770 Folsom.
Seattle, 416 American Bank Bldg.

American Electrical Heater Co. ...
Detroit, U. S. A.

Aylsworth Agencies Co. ...
San Francisco, 143 Second.

B

Barnes-Lindsley Mfg. Co. ... 13
Portland, Ore.

Bay Cities Home Telephone Co. ..
San Francisco, 333 Grant Ave.

Benjamin Electric Mfg. Co. ...
New York, 27 Thames.
Chicago, 120-128 S. Sangamon.
San Francisco, 151 New Montgomery.

Blake Signal and Mfg. Co. ... 2
Boston, 246 Summer.

Bonestell & Co. ... 5
San Francisco, 118 First.

Bridgeport Brass Company ... 4
Bridgeport, Conn.

C

Chicago Fuse Mfg. Co. ...
Chicago, 1014 - 1020 W. Congress.
New York, 1 Hudson.

Colonial Electrical Agency Co. ...
San Francisco, 576 Mission.

Crocker-Wheeler Co. ...
San Francisco, 196-7 Fremont.

D

D. & W. Fuse Co. ...
Providence, R. I.

Dearborn Drug & Chem. Works ... 13
Chicago, Postal Bldg.
San Francisco, 301 Front.
Los Angeles, 355 E Second

Duncan Elec. Mfg. Co. ... 5
Lafayette, Indiana.
San Francisco, 61 Second.

E

Economy Electric Co., The ...
Warren, Ohio.

Electric Cntrlr & Mfg. Co., The ...
New York, 50 Church.
Pittsburg, 515 Frick Bldg.
Chicago, 135 Adams.
Birmingham, 827 Brown-Marx Bldg.

Electric Goods Mfg. Co. ...
Boston, Mass.
San Francisco, 165 Second.

Electric Storage Battery Co. ...
Philadelphia, Pa.
San Francisco, Monadnock Bldg.

F

Fairbanks, Morse & Co. ...
Chicago, 481 Wabash ave.
San Francisco, 158 First.
Los Angeles, 423 E. Third.

Farnsworth Electrical Works ... 1
San Francisco, 132 - 138 Second.

Fort Wayne Electric Works ... 11
Fort Wayne, Ind.
San Francisco, 604 Mission.
Seattle Colman Bldg.

G

General Electric Co. ... 14
Schenectady N. Y.
San Francisco, Union Trust Bldg.
Los Angeles, 124 W. Fourth.
Seattle, Colman Bldg.
Portland, Worcester Bldg.
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Columbus, O.
Denver, Colo.
Detroit, Mich.
Indianapolis, Ind.
Kansas City, Mo.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Philadelphia, Pa.
Pittsburg, Pa.
Richmond, Va.
Salt Lake City, Utah.
St. Louis, Mo.
Syracuse, N. Y.
Spokane, Wash.

Goeriz, O. C. & Co. ...
San Francisco, 916 Postal Tel. Bldg.

Gould Storage Battery Co. ... 16
San Francisco, 604 Mission.

H

Habirshaw Wire Co. ...
New York, 253 Broadway.

Hammel Oil Burner Company ...
Los Angeles, 640 N. Main.

Hitchcock Military Academy ... 12
San Rafael

Holtzer-Cabot Elec. Co., The ...
Boston and Chicago.
San Francisco, 612 Howard.

Hughes & Co., E. C. ... 2
San Francisco, 147 - 151 Minna.

Hunt, Mirk & Co. ...
San Francisco, 141 Second.

I

Indiana Rubber & Ins. Wire Co. ... 16
Jonesboro, Indiana.

J

Johns-Manville Co., H. W. ... 5
New York, 100 William.
San Francisco, 159 New Montgomery.
Los Angeles, 222-224 North Los Angeles.
Seattle, 576 First Ave. So.

K

Kellogg Switchb'd & Supply Co. ..
Chicago.
San Francisco. 88 First.

Kelman Electric & Mfg. Co. ...
Los Angeles, Cal.

Klein & Sons, Mathias ... 2
Chicago, Station U-29.

L

Locke Insulator Mfg. Co. ...
Victor, N. Y.
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electrical Bldg.
Seattle, Colman Bldg.

M

Machinery & Supply Co. ...
San Francisco, Seventh & Harrison.

Moore, Chas. C. & Co. Engineers. 3
San Francisco, 99 First.
Los Angeles, American Bank Bldg.
Seattle, Mutual Life Bldg.
Portland, Wells-Fargo Bldg.
Salt Lake City, Atlas Blk.
New York City, Fulton Bldg.
Tucson, Arizona.

N

New York Ins'l'd Wire Co. ...
New York, 114 Liberty.
San Francisco, 770 Folsom.
Seattle, 416 American Bank Bldg.

O

Ohio Brass Co. ... 2
Mansfield, Ohio.
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electric Bldg.
Seattle, Colman Bldg.

Okonite Co. ... 16
New York, 253 Broadway.

P

Pacific Gas & Elect. Co., The ... 13
San Francisco.

Pacific Meter Co. ... 13
San Francisco, 311 Santa Marina Bldg.

Pacific Tel. & Tel. Co., The ...
San Francisco.

Partrick Carter & Wilkins Co. ...
Philadelphia, Twenty-second and Wood.

Pelton Water Wheel Co., The ... 13
San Francisco, 2219 Harrison.

Pierson, Roeding & Co. ... 4
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electric Bldg.
Seattle, Colman Bldg.

Portland Wood Pipe Co. ... 2
Portland, Ore.

S

Schaw-Batcher Co. Pipe Works ...
Sacramento, Cal., 211 J.
San Francisco, 356 Market.

Southern Pacific Co. ... 16
San Francisco, Flood Bldg.

Sprague Electric Co. ... 5
New York City, 527-531 W. Thirty-fourth.
San Francisco, Atlas Bldg.
Seattle, Colman Bldg.

Standard Und. Cable Co. ... 16
San Francisco, First National Bank Bldg.
Los Angeles, Union Trust Bldg.

Sterling Paint Company, ...
San Francisco, 118 First.

T

Technical Book Shop ... 11
San Francisco, 604 Mission.

Thomas and Sons Co., R. ...
New York, 227 Fulton.
East Liverpool, Ohio.

Thompson Co., The Chas. C. ...
Chicago, 545-549 Wabash ave.

Tracy Engineering Co. ...
San Francisco, 461 Market.
Los Angeles, Central Bldg.

W

Wagner Electric Mfg. Co. ...
St. Louis, Mo.

Western Electric Co. ... 5
San Francisco, 680 Folsom.
Oakland, 507 Sixteenth.
Los Angeles, 119 E. Seventh
Seattle, 1518 First Ave. So.

Western Wireless Equipment Co. ..
San Francisco, Grant Bldg., Seventh and Market.

Westinghouse. Elec. & Mfg. Co. ... 6
Pittsburg, Pa.
Los Angeles, 527 So. Main.
Denver, 429 Seventeenth.
Seattle, Central Bldg.
Salt Lake City, 212-214 So. W. Temple.
San Francisco, 165 Second.
Spokane, Columbia Bldg.
Portland, Couch Bldg.
Butte, Lewisohn Bldg.
Canada, Canadian - Westinghouse Co., Ltd., Hamilton, Ontario.
Mexico., G. & O., Braniff & Co., City of Mexico.

Westinghouse Machine Co. ...
Pittsburg, Pa.
San Francisco, 141 Second.

Weston Elect'l. Instrument Co. ... 3
Waverly Park, N. J.
New York, 114 Liberty.
San Francisco, 682 - 684 Mission.

Wilbur, G. A. ... 5
San Francisco, 61 Second.